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SECTION A.—PHYSICS.

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Abstract No. 123, lines 8 and 12 : *for* Colpitt, *read* Colpitts.
Abstract No. 75, line 1 : *for* G. E. K. Mees, *read*, C. E. K. Mees.
Abstract No. 253, line 2 : *for* H. D. Smith, *read* H. D. Smyth.
Abstract No. 380, line 5 : *for* Schwarzchild, *read* Schwarzschild.
Abstract No. 399, line 2 : *for* Yamamotu, *read* Yamamoto.
Abstract No. 400, line 2 : *for* Furner, *read* Turner.
Abstract No. 604, line 4 : *for* cuve, *read* cube.
Abstract No. 671, p. 277, line 6 : *for* less three, *read* less than three.
Abstract No. 1009, line 23 : *for* Metrological, *read* Meteorological.
Abstract No. 1161, p. 452, line 9 : *for* $(1 - 6^2)$, *read* $(1 - b^2)$.
Abstract No. 1182, line 3 : *for* Thompson, *read* Thomson.
Abstract No. 1200, line 3 : *for* Schwartzschild, *read* Schwarzschild.
Abstract No. 1215, line 10 : *for* isohyets, *read* isohels.
Abstract No. 1218, p. 484, line 3 : *for* r, *read* τ.
Abstract No. 1252, line 5 : *for* 183 (1918), *read* 183 (1919).
Abstract No. 1319, line 2 : *for* Ruffs, *read* Ruff.
Abstract No. 1356, line 2 : *for* A. Fuchs, *read* S. Fuchs.
Abstract No. 1380, line 9 : *for* in the, *read* for the.
Abstract No. 1417, line 8 : *for* 4000° K., *read* 7000° K.
Abstract No. 1434, line 2 : *for* Rabel, *read* Rahel.
Abstract No. 1510, line 6 : *for* porportional, *read* proportional.
Abstract No. 1516, p. 596, line 22 : *for* Clairant, *read* Clairault.
Abstract No. 1522, line 8 : *for* 218 (1920), *read* 418 (1920).
Abstract No. 1592, line 3 : *for* J. G. Barber, *read* I. G. Barber.

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LIST OF JOURNALS & ABBREVIATIONS USED THEREFOR

Abbreviation.	Full Title.
Accad. Lincei, Atti	Atti della Reale Accademia dei Lincei, Roma.
Accad. Sci. Med. e. Nat., Ferrara	Accademia della Scienze Medicale et Naturale, Ferrara.
Accad. Sci. Torino, Atti	Atti della Reale Accademia delle Scienze di Torino.
Aircraft Engineering	Aircraft Engineering.
Akad. Wiss. Wien, Ber.	Sitzungsberichte der Akademie der Wissenschaften, Wien, Mathematischnaturwissenschaftliche Klasse.
Am. Acad., Proc.	Proceedings of the American Academy of Arts and Sciences.
Am. Chem. Soc., J.	Journal of the American Chemical Society.
Am. Electrochem. Soc., Trans.	Transactions of the American Electrochemical Society.
Am. Illum. Eng. Soc., Trans.	Transactions of the American Illuminating Engineering Society.
Am. I.E.E., J.	Journal of the American Institute of Electrical Engineers.
Am. Inst. Mining Eng., Bull.	Bulletin of the American Institute of Mining Engineers (now Mining and Metallurgy).
Am. J. Sci.	American Journal of Science.
Am. Phil. Soc., Proc.	Proceedings of the American Philosophical Society.
Am. Soc. for Testing Mat.	American Society for Testing Materials.
Am. Soc. Mech. Eng., J.	Journal of the American Society of Mechanical Engineers (now Mechanical Engineering).
Ann. de l'Obs. Astron. de Tokyo	Annales de l'Observatoire Astronomique de Tokyo.
Ann. de Physique	Annales de Physique.
Ann. d. Physik	Annalen der Physik.
Annales des Postes, Télé.	Annales des Postes, Télégraphes et Téléphones.
Arch. d'El. Médicale	Archives d'Électricité Medicale.
Arch. des Sciences	Archives des Sciences Physiques et Naturelles, Genève.
Archiv f. Elektrot.	Archiv für Elektrotechnik.
Ark. f. Mat. Astron. och Fysik, Stockholm,	Arkiv för Matematik, Astronomie och Fysik, Stockholm.
Assoc. Ing. El. Liége, Bull.	Association des Ingénieurs Électriciens, Bulletin, Institut Electrotechnique Montefiore, Liége.
Astron. J.	Astronomical Journal.
Astron. Nachr.	Astronomische Nachrichten.
Astron. Soc. Pacific, Publ.	Publications of the Astronomical Society of the Pacific.
Astronomie	L'Astronomie.
Astrophys. J.	Astrophysical Journal.
Automotor J.	Automotor Journal.
Bull. Astronomique	Bulletin Astronomique.
Bureau of Mines, Techn. or Sci. Papers	Technical or Scientific Papers of the Bureau of Mines (U.S. Department of the Interior).
Bureau of Standards, Bull.	Bulletin of the Bureau of Standards, Washington.
Calcutta Math. Soc., Bull.	Bulletin of the Calcutta Mathematical Society.
Cambridge Phil. Soc., Proc.	Proceedings of the Cambridge Philosophical Society.
Cambridge Phil. Soc., Trans.	Transactions of the Cambridge Philosophical Society.
Canad. Elect. News	Canadian Electrical News.
Chem. and Met. Eng.	Chemical and Metallurgical Engineering.
Chem. News	Chemical News and Journal of Physical Science.

Abbreviation.	Full Title.
Chem. Soc. J., Trans.	Journal and Transactions of the Chemical Society of London.
Comptes Rendus	Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences.
Danske Vidensk. Selskabs., Med.	Meddelelser det kgl. danske Videnskabernes Selskabs.
Dominion Obs. Ottawa, Publ.	Publications of the Dominion Observatory, Ottawa.
Elect. J.	Electric Journal.
Electrician	The Electrician.
Electricien	L'Electricien.
Electrot. Laborat. Tokyo, Japan, Researches	Researches of the Electrotechnical Laboratory, Tokyo, Japan.
Elek. u Maschinenbau	Elektrotechnik und Maschinenbau.
Elekt. Zeits.	Elektrotechnische Zeitschrift.
Elettricità, Milan	L'Elettricità, Milan.
Elettrotecnica	L'Elletrotecnica.
El. Rev.	The Electrical Review (London).
El. Rev., Chicago	The Electrical Review, Chicago.
El. Rly. J.	Electric Railway Journal.
El. Times	Electrical Times.
El. World	Electrical World.
Eng. Club Phil., J.	Journal of the Engineers' Club of Philadelphia (now Engineers and Engineering)
Engineer	Engineer.
Engineering	Engineering.
Eng. News-Record	Engineering News-Record.
Faraday Soc., Trans.	Transactions of the Faraday Society.
Frank. Inst., J.	Journal of the Franklin Institute.
Gen. El. Rev.	General Electrical Review.
Illum. Eng., London	Illuminating Engineer.
Indian Assoc. for Cultivation of Science, Proc.	Proceedings of the Indian Association for Cultivation of Science.
Inst. Civ. Eng., Proc.	Proceedings of the Institution of Civil Engineers.
Inst. El. Eng., J.	Journal of the Institution of Electrical Engineers.
Inst. El. Eng. of Japan, J.	Journal of the Institution of Electrical Engineers of Japan.
Inst. Eng. and Shipbuilders, Trans.	Transactions of the Institution of Engineers and Shipbuilders in Scotland.
Inst. Mech. Eng., J.	Journal of the Institution of Mechanical Engineers.
Inst. Naval Architects, Trans.	Transactions of the Institution of Naval Architects.
Inst. Radio Eng., Proc.	Proceedings of the Institute of Radio Engineers.
Iron and Steel Inst., J.	Journal of the Iron and Steel Institute.
Jahrb. d. drahtl. Tele.	Jahrbuch der Drahtlosen Telegraphie und Telephonie.
Jahrb. d. Radioakt.	Jahrbuch der Radioaktivität und Elektrotonik.
J. de Physique et le Radium	Le Journal de Physique et le Radium.
J. Phys. Chem.	Journal of Physical Chemistry.
Journ. Télégraph.	Journal Télégraphique.
K. Akad. Amsterdam, Proc.	Proceedings of the Koninklijke Akademie van Wetenschappen te Amsterdam.
Kyoto Coll. Sci., Mem.	Memoirs of the College of Science, Kyoto Imperial University.
Kyushu Univ. Coll. Eng., Mem.	Memoirs of the Kyushu Imperial University College of Engineering.
La Plata Univ. Publ. [ser. fis. mat], [ser. tecn.]	Universidad Nacional de la Plata, Publicaciones.
Lick Observat., Bull.	Bulletin of the Lick Observatory.
Manchester Phil. Soc., Mem.	Memoirs and Proceedings of the Manchester Literary and Philosophical Society.
Mechanical Engineering	*See* Am. Soc. Mech. Eng.
Meteorolog. Obs. Japan, Bull.	Bulletin of the Meteorological Observatory, Japan.
Meteorlog. Office, Prof. Notes	Professional Notes of the Meteorological Office

Abbreviation.	Full Title.
Meteorolog. Zeits.	Meteorologische Zeitschrift.
Mining and Metallurgy	Bulletin of the American Institute of Mining and Metallurgical Engineers.
Monthly Weather Rev.	Monthly Weather Review.
Nat. Acad. Sci., Proc.	Proceedings of the National Academy of Sciences.
Nat. Research Council, Bull.	Bulletin of the National Research Council.
Nature	Nature.
N. Cimento	Nuovo Cimento.
New Zealand J. of Sci.	New Zealand Journal of Science and Technology.
Observatory	The Observatory.
Onde Élec.	L'Onde Electrique, Paris.
Optical Soc. America, J.	Journal of the Optical Society of America.
Optical Soc., Trans.	Transactions of the Optical Society.
Phil. Mag.	Philosophical Magazine and Journal of Science.
Phot. J.	Photographic Journal.
Phys. Math. Soc. Japan, Proc.	Proceedings of the Physico-Mathematical Society of Japan.
Phys. Rev.	Physical Review.
Phys. Soc., Proc.	Proceedings of the Physical Society of London.
Phys. Zeits.	Physikalische Zeitschrift.
Power	Power.
Preuss. Akad. Wiss. Berlin, Ber.	Sitzungsberichte der Preussischen Akademie der Wissenschaften zu Berlin.
Radioélectricité	Radioélectricite.
Radio Rev.	Radio Review.
Rev. de Mét.	Revue de Métallurgie.
Rev. Gén. d'El.	Revue Générale de l'Electricité.
Riv. Ottica e Meccan.	Rivista d'Ottica e Meccanica di Precisione.
Röntgen Soc., J.	Journal of the Röntgen Society.
Roy. Astron. Soc. Canada, J.	Journal of the Royal Astronomical Society of Canada.
Roy. Astron. Soc., M.N.	Monthly Notices of the Royal Astronomical Society.
Roy. Dublin Soc., Proc.	Proceedings of the Royal Dublin Society.
Roy. Irish Acad., Proc.	Proceedings of the Royal Irish Academy.
Roy. Meteorlog. Soc., J.	Quarterly Journal of the Royal Meteorological Society.
Roy. Soc. Canada, Trans.	Transactions of the Royal Society of Canada.
Roy. Soc. Edinburgh, Proc.	Proceedings of the Royal Society of Edinburgh.
Roy. Soc., Phil. Trans.	Philosophical Transactions of the Royal Society of London.
Roy. Soc., Proc.	Proceedings of the Royal Society of London.
Roy. Soc. Tasmania, Proc.	Proceedings of the Royal Society of Tasmania.
Roy. Soc. Victoria, Proc.	Proceedings of the Royal Society of Victoria.
Schweiz. Elektrot. Verein, Bull.	Bulletin des Schweizerischen Elektrotechnischen Vereins.
Smithsonian Misc. Coll.	Smithsonian Miscellaneous Collections.
Soc. Arts, J.	Journal of the Royal Society of Arts.
Soc. Belge Élect., Bull.	Bulletin de la Société Belge des Electriciens.
Soc. Chim. Pologne, Ann.	Roczniki Chemji, Warszawa.
Soc. Franç. Elect., Bull.	Bulletin de la Société Française des Électriciens.
Soc. Spettros. Ital., Mem.	Memorie della Società degli Spettroscopisti Italiani.
Teleg. u. Fernspr. Techn.	Telegraphen und Fernsprech Technik.
Teleg. without Wires, Russia	Telegraphy and Telephony without Wires, Nijnij-Nowgorod.
Terrest. Magn.	Terrestrial Magnetism and Atmospheric Electricity.
Tôhoku Math. J.	Tôhoku Mathematical Journal.
Tôhoku Univ., Sci. Reports	Science Reports of the Tôhoku Imperial University.
Tokyo Univ. Coll. of Eng., J.	Journal of the Tokyo Imperial University College of Engineering.
T. S. F.	Télégraphie sans Fil: Revue Mensuelle de Radiotélégraphie et Radiotéléphonie.

Abbreviations.	Full Title.
Union Obs. S. Africa, Circ.	Circulars of the Union Observatory of South Africa.
Univ. of Illinois Eng. Exp. Sta., Bull.	Bulletin of the Engineering Experiment Station of the University of Illinois.
Washington Acad. Sci., J.	Journal of the Washington Academy of Sciences.
West. Soc. Eng., J.	Journal of the Western Society of Engineers.
Wireless Age.....	Wireless Age.
Yerkes Observat., Publ.	Publication of the Yerkes Observatory.
Zeits. angew. Chem.	Zeitschrift für angewandte Chemie.
Zeits. anorg. Chem.....	Zeitschrift für anorganische Chemie.
Zeits. Elektrochem.....	Zeitschrift für Elektrochemie.
Zeits. f. Metallkunde	Zeitschrift für Metallkunde (formerly Internationale Zeitschrift für Metallographie).
Zeits. f. Physik	Zeitschrift für Physik.
Zeits. Instrumentenk.	Zeitschrift für Instrumentenkunde.
Zeits. Instrumentenk., Beib.	Deutsche-Mechaniker-Zeitung. Beiblatt zur Zeitschrift für Instrumentenkunde.
Zeits. Math. u. Mechanik	Zeitschrift für angewandte Mathematik und Mechanik.
Zeits. phys. Chem.	Zeitschrift für physikalische Chemie.
Zeits. techn. Physik.	Zeitschrift für technische Physik.
Zeits. Vereines deutsch. Ing.....	Zeitschrift des Vereines deutscher Ingenieure.
Zeits. wiss. Phot.	Zeitschrift für wissenschaftliche Photographie, Photophysik und Photochemie.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JANUARY 1921.

GENERAL PHYSICS.

1. *New Apparatus for Measuring the Stress and Strain around a Bolt.* **D. Rühl.** (Zeits. Vereines Deutsch. Ing. 64. pp. 549–554, July 17, 1920.)—Describes a new form of apparatus for measuring the strain and stress distribution around a bolt hole when force is applied to the bolt. A diagram is given for the lines of stress distribution about the hole in the case of a single iron plate held in tension between bolts inserted at each end. J. W. T. W.

2. *Glass-to-Metal Joints.* **E. C. McKelvy** and **C. S. Taylor.** (Am. Chem. Soc., J. 42. pp. 1364–1374, July, 1920.)—Reference is made to the various glass-to-metal joints previously described, and descriptions are then given of those used in the laboratories of the U.S. Bureau of Standards, these consisting of (1) soldered joints or (2) fused joints. In those of the first type, which are used only for joining tubing, the glass tube is chosen so as to fit snugly for 15–20 mm. of its length into the metal tube, and conveniently fits against a shoulder in the latter. The inside of the metal tube is tinned to the shoulder with commercially pure tin, a slight excess of tin being left on the surface, especially if the tubes do not fit very closely; common solder or pure lead has been successfully used in place of tin. The glass tube, roughened slightly with sand or emery paper, is platinised over a length of 20 mm. or more by application of a colloidal solution of platinum in lavender oil mixed with Burgundy pitch, and then heated carefully to drive off the volatile material and afterwards to an incipient red heat to burn off all the carbonaceous material and fuse the platinum into the glass. With the help of a slightly acid solution of zinc chloride as soldering flux, the two parts are heated gradually over a bunsen flame until the tin is well melted, the glass part being inserted into the metal tube and the whole allowed to cool slowly and uniformly.

For fused joints use is made of the Kraus flux, prepared by melting in a crucible equal weights of zinc oxide, borax, and powdered soda glass. The end of the metal tube in the form of a cylindrical or conical shell is lined with a thin layer of the flux, while the glass tube is flared out to a flat ring of a width one to three times the wall-thickness. The tube and shell are heated and the tube introduced into the shell, fusion being completed by heating the outside of the shell in such a way as to keep the glass tube cool enough to avoid deformation. T. H. P.

3. *Riefler Pendulum.* **H. Kienle.** (Zeits. Instrumentenk. 40. pp. 173–179, Sept., 1920.)—This paper gives a theoretical discussion of a special Riefler nickel-steel compensation pendulum. This pendulum, besides the usual compensation arrangement which serves as the pendulum bob, has a tubular attachment in the middle to compensate for the effect of varying temperature along the length of the rod. Numerical data are given relative to the behaviour of such a pendulum during fourteen months. A. W.

4. *Reduction of Error by Linear Compounding.* **W. F. Sheppard.** (Roy. Soc., Phil. Trans. 221. pp. 199–237, Oct. 22, 1920.)—This treatise, which is entirely mathematical, is a development of two earlier papers by the author, termed by him " Reduction " and " Fitting " respectively (Fifth Internat. Congress of Mathematicians, ii. p. 348, 1912, and London Math. Soc. 13, p. 97). L. H. W.

5. *Methods of Measuring Variations in Gravity.* **C. Barus.** (Nat. Acad. Sci., Proc. 6. pp. 495–502, Aug., 1920.)—I. Some gas is placed in a cartesian diver, the top of which is closed, while below the gas is liquid passing down a capillary tube to a closed vessel of liquid. By change in hydrostatic pressure in the vessel it is possible to sink the diver. If g varies, the head of liquid necessary for sinking the diver also varies, and thus we can determine changes in gravity, with the possible accuracy of 1 in 10^4. In an apparatus actually used alteration of temperature causes the air above the water in the diver to dissolve when temperature falls and be released from solution when temperature rises. This militates against accurate results.

II. In a torsional apparatus the pull of gravity is balanced against the torsion of a steel wire. If the latter is constant, while gravity changes, we shall have the torsion beam rotating. The small movement thus produced is measured by interference methods, using the Michelson form of apparatus. The errors arising in practice are referred to decrease in rigidity with rise in temperature. It is suggested that by using Guillaume's alloys this trouble may be avoided. P. E. S.

6. *Thermal Filters.* **W. D. Bancroft.** (Journ. Phys. Chem. 24. pp. 421–436, June, 1920.)—This paper consists mainly of a long quotation from Aitken's work on the removal of dust from air by taking advantage of the fact that the dust particles tend to move away from hot bodies and to attach themselves to cold ones (Roy. Soc. Edinburgh, Trans. 32. p. 239, 1884). To account for this phenomenon it is suggested that each particle of dust is surrounded by a film of adsorbed air and that this film will be diminished if the particle is heated on one side, air then flowing

round the particle from the cooler to the warmer side and tending to restore the equilibrium. A movement of the particle towards the cooler portions of the space thus takes place. Hence the particle would be sucked towards the cooler zone, whereas Aitken considered it to be driven from the hotter one. T. H. P.

7. *Rate of Self-Diffusion of Fused Lead.* **J. Gróh** and **G. v. Hevesy.** (Ann. d. Physik, 63. 1. pp. 85–92, Sept. 16, 1920.)—In ordinary diffusion experiments the possibility of reactions between the particles and the medium is not excluded. In order to study the self-diffusion of particles in a medium of the same substance in the sense of Maxwell, the particles should be marked in some way. The authors do this by observing the rate of diffusion of radio-active lead from thorium B through ordinary lead. The masses of the two substances differ, being 212 and 207·1 respectively; that, however, should not affect the rate of diffusion, which for equal temperatures should depend only on the radius of the particles. The experiments are made by fusing, within a glass tube of 3 mm. diameter, first 1·5 cm. of radio-active lead, and then above it 4·5 cm. of ordinary lead, all in a high vacuum. The solidified cylinder of lead is then heated for 2 days to 343°, *i.e.*, above the melting-point of lead; the cold cylinder is cut into four equal rods, which are rolled down to thin foil and tested for radio-activity. The difficulty of the experiments is that the glass tubes crack and that the fused lead evolves gas. The rate of diffusion found at 343° is 2·2 cm.^{2} per day. Reduced to ordinary temperature and to the viscosity of water, that figure would be about 3 times as large as the rate of diffusion of the lead ion in water.

Size of the Lead Ion.—It is concluded that the radius of the lead ion is, owing to hydration, at least 3 times as large as that of the lead atom or molecule. H. B.

8. *Effects of Holes and Cracks in Ships' Plating.* **E. G. Coker** and **A. L. Kimball, Jr.** (Inst. Naval Architects, Trans. 62. pp. 117–123; Disc., 123–128, 1920. Engineering, 109. pp. 840–842, June 18, 1920.)—A continuation of previous work, the photo-elastic study of the effect of holes in materials under strain [see Abs. 297 (1911), 1773 (1913), and 182 (1920)]. The particular cases here dealt with are (i) an elliptical hole, (ii) a slit with an elliptical hole at each end, and (iii) a square hole with rounded corners. J. W. T. W.

9. *Fatigue Strength of Carbon Spring-Steel.* **E. P. Stenger** and **E. H. Stenger.** (Chem. and Met. Eng. 23. pp. 635–636, Sept. 29, 1920. Abstract of paper read before the Am. Soc. for Steel Treating.)—The number of repetitions of stress, required to cause fatigue failure bears a logarithmic relation to the max. fibre stress, and there is no break in the curve at the elastic limit. The number of repetitions depends upon the difference between the maximum and minimum stresses imposed. There is a certain range which will allow an infinite number of repetitions without failure, but this narrows as the max. stress increases. Up to 2000 revs. per min. the fatigue stress is independent of the speed. Rest and repeated tempering below Ac1 do not increase the endurance of unhardened steel. The effect of cold work varies. The endurance of the metal is a maximum at 300–400° C. In the carbon steels, the endurance is greatest with hardened eutectoid steel. For a steel with 1·03 % C and 0·45 % Mn

the best resistance is obtained by quenching from just above the cementite line, 1500° F. When then tempered until the structure is entirely troostite, 600–650° F., the highest strength is obtained. Re-shaped springs fail very quickly. F. C. T.

10. *The Strength of Struts.* **R. V. Southwell.** (Aircraft Engineering, pp. 22–24, Jan.; 43–46, Feb.; 82–85, March; 111–114, April; and pp. 135–138, May, 1920.)—A review of progress made in theory and experiment during the war. The general theory of strut failure is briefly discussed in Section 1, and indications are given of the way in which the original theory of Euler may be extended so as to explain the differences exhibited by experimental curves for struts of ductile and of brittle materials: emphasis is laid upon the exact physical significance of Euler's "critical load," and an explanation is given of its being reached approximately in long, but not in short struts. The importance of the "yield" phenomenon is also emphasised, and the derivation of the Air Board Standard Curves for steel tubular struts (which are based on this) is explained.

Section 2 deals with struts of varying cross-section: the work of Barling and Webb, on max. weight economy, is explained with the help of a simplified example, and a series of exact solutions for struts of special type is described, references being given to original papers by Webb, Lang, Cowley, and Levy. The general problem (of finding the critical load for a strut of *any* specified form) is then explained, and the methods of Griffith, Case, Cowley and Levy, Morley, Bairstow, and Stedman are described; to complete the section, an original graphical method, of complete generality, is propounded, for which an accuracy within 1 % is claimed.

In Section 3, various outstanding problems in the theory and application of the subject are reviewed, and the paper concludes with an account of work done by the author in conjunction with the late W. C. M. Pettingill, in which the foundations are laid for a treatment of complex struts (such as are employed in rigid airship construction) by dimensional theory. AUTHOR.

11. *Rubber Energy.* **W. B. Wiegand.** (Chem. and Met. Eng. 23. pp. 740–742, Oct. 13, 1920. Abstract of paper read before the Am. Chem. Soc., Sept., 1920.)—The hysteresis loss in rubber—the difference between input (extension curve) and output (retraction curve)—is large, but diminishes as the cycles are repeated and with rising temperature (Schwartz); hence Shedd and Ingersoll speak of "viscosity loop." Thermodynamically rubber stands between gases, which develop thermal effects when expanded or compressed, and steel springs, in which the work done appears as potential energy almost without heat development. The author exemplifies this peculiarity by a model which he utilises as a machine for rubber testing. When rubber is stretched, heat is given off, and part of this heat is irreversible or lost; in curing rubber we should search for compounds which will keep this lost heat at a minimum. He also tests rubber tyres by cutting thin sections, clamping the one end to a rafter and suspending a pendulum from the other end: he then watches the damping of the whole section after removing the plies one after the other. The hysteresis loss of all the rubber in the section was found to be equal to that of one ply of the fabric. In the *discussion*, the high

value of the paper was acknowledged. **C. O. North** illustrated a new type of stress-strain curing curve. H. B.

12. *The Ball Test for Hardness.* **T. Baker** and **T. F. Russell.** (Iron and Steel Inst., J. 101. pp. 341–356 ; Disc., 357–358, 1920.) Engineering, 109. pp. 698–700, May 21, 1920.)—The object of the experimental work described was to ascertain the significance of the constants in the formulæ $L = bV^m$ and $L = ad^n$, in which L is the load in the Brinell test, V the volume of the indentation, and d the diam. of the impression. The constants a and b indicate respectively the value of the load necessary to produce an impression of unit diameter and that to give unit volume. The constants m and n are shown to be measures of the cold work put upon the material. It is shown that n gradually diminishes as the cold work on the specimen increases and in completely cold-worked material it approximates to a value equal to 2. C. O. B.

13. *Turbulent Fluid Motion and Skin Friction.* **T. H. Havelock.** (Inst. Naval Architects, Trans. 62. pp. 175–182 ; Disc., 182–184, 1920. Engineering, 109. pp. 737–738, May 28, 1920.)—Problems concerning skin friction are critically reviewed, and the problem of the distribution of surface velocity receives special consideration. It is generally assumed that when a liquid flows through a pipe in steady turbulent motion the surface velocity is zero. In many cases it is found that the velocity varies but little over a large part of the cross-section and is an appreciable fraction of the mean velocity at points very near the wall. The resistance to motion is calculated from an expression involving the square of the relative velocity at a point. Where the distribution of the surface velocity over an immersed body is known, the total skin friction can be calculated by integrating the expression. An extension to curved surfaces is made. The application of the law of similarity to planks is also discussed. It is pointed out that the undetermined function depends on the ratio of the breadth to the length, but in most experiments (including those of Froude) this ratio has not been kept constant, for the breadth remained constant whilst the length varied. Finally the application of the method of obtaining friction from the distribution of the surface velocity is applied to the general problem of ship resistance. W. A. R.

14. *Boundary Conditions of Fluid in Turbulent Motion.* **T. E. Stanton, D[orothy] Marshall,** and **[Mrs.] C. N. Bryant.** (Roy. Soc., Proc. 97. pp. 413–434, Aug. 3, 1920.)—The experiments here described form part of a general research, at the National Physical Laboratory, into the friction of solid surfaces due to the flow over them of fluids whose motion is turbulent out of the immediate neighbourhood of the surface.

Practically nothing is known of the mechanism transmitting the resistance to flow to the bounding surfaces. It is generally accepted that the fluid layer in contact with the surface is at rest relatively thereto at speeds below the critical, since sensible slip would be detected by variation from Poiseuille's law relating the diameter of a pipe and the rate of efflux. At speeds above the critical, observations near the walls have shown that the mean velocity falls rapidly near the boundary, and the existence there of a thin layer with laminar flow has been suggested. The frictional resistance, in the absence of slip, should then be deter-

minable from the shape of the velocity curve in the surface layer and the viscosity coefficient of the fluid, and attempts have been made to effect the determination by setting up a condition of turbulent motion over a surface of which the frictional resistance to the flow could be accurately determined, and measure the fluid velocity as near the wall as possible by means of a very fine Pitot tube. The main difficulties involved are to determine the interference in the flow near the boundary due to the presence of the tube, and to ensure that the speed deduced from the pressure in the Pitot tube is the speed at its geometrical centre.

The *results* of the long series of experiments described in the paper, which are tabulated and plotted as curves, appear amply to warrant the conclusion arrived at to the effect that in turbulent motion there exists at the boundary a layer of fluid of finite thickness, which is in laminar motion, and which has zero velocity at the boundary, so that the boundary conditions are expressible in the form : $\mu Lt(dv/dx) \longrightarrow o = R$, where the origin is taken in the boundary, x is measured along the normal, v the velocity parallel to the boundary, μ the coefficient of viscosity of the fluid, and R the intensity of surface friction. The authors infer from their own results that the conclusion of Morrow [Abs. 1319 (1911)] that at speeds below the critical, the theoretical velocity distribution across any section given by $V = V_c(1 - r^2/a^2)$, where V_c is the velocity at the axis of a pipe of radius a, is incorrect, is an error partly due to a small inaccuracy in calibrating the Pitot tube, and partly to the fact that his tube was at a distance of about 30 diameters from the inlet end of his pipe, where, according to their results, the radial distribution would not have attained steady conditions. G. W. DE T.

15. *On the Oscillation of the Beaded String.* **S. Suzuki.** (Phys. Math. Soc. Japan, Proc. 2. pp. 185–192, Sept., 1920.)—Investigates the case of the small oscillations of a row of beads, at equal intervals, connected by a weightless flexible string fixed at the upper and free at the lower end, and then the transition state to the continuous heavy flexible chain. L. H. W.

16. *Relativity.* **K. F. Bottlinger.** (Astron. Nachr. No. 5051. Nature, 106. p. 66, Sept. 9, 1920.—Abstract.)—The author suggests a possible test to distinguish between the earlier view of a stationary æther and the modern relativist theory. Spiral nebulæ and clusters show very high radial velocity, so that it is likely that the velocity of our system relative to the æther is of the same order. Assuming it to be 1000 km./sec. and in a direction not far out of the ecliptic, eclipses of Jupiter's satellites will be alternately accelerated and retarded by some 14 secs. according as Jupiter lies towards the apex or the antapex. Harvard series of observations of eclipses of these satellites show no such possible variation, so that either the æther is not fixed, or else the solar system is moving very much more slowly than 1000 km./sec. This should be a first-order effect; the Michelson-Morley experiment being only a second-order effect. W. W. B.

17. *Determination of Meteorological Corrections on the Ranges of Guns.* **W. Noll.** (Monthly Weather Rev. 47. pp. 868–869, Dec., 1919.)—A projectile in its flight spends more time in the upper part of the trajectory because of its lower vertical velocity, so that when correcting for range

and deflection the winds in the upper regions have more time to affect the range or deflection of the projectile and should be given more consideration or weight than the winds lower down. The less dense air composing these upper winds and the decreased horizontal velocity are other factors that must be taken into consideration in order properly to determine the weight that the winds at various heights should be given.

The resistance offered a projectile in its flight varies with the density of the air, other factors being constant. The density aloft is computed from values of pressure and temperature determined from aeroplane flights. The ratio of observed to normal is then computed and used in making the corrections.

A change in the velocity of sound arising from a change in temperature has the effect of changing the air-resistance law of a projectile; hence changing the range of a projectile. Ballistic temperature is computed from values obtained from aeroplane observations of temperature and by the use of temperature weighting factor curves. These curves are of such a nature that the ballistic temperature may be lower than the lowest actual temperature. AUTHOR.

18. *Non-Integrability of the Distance Transfer and the World Function in the Weyl Generalised Theory of Relativity.* **E. Reichenbächer.** (Ann. d. Physik, 63. 2. pp. 93–114, Sept. 28, 1920.)—The Einstein demand for the invariance of natural laws with respect to every transformation of coordinates has been assumed by Weyl to apply to every change of gauge, and, in consequence, emphasises in the sharpest possible manner the relativity feature in the conception of total phenomena in inanimate Nature. The present author opines that this absolute standpoint is open to question, and submits it to critical examination. Starting from the arbitrary character of the gauge, he points out that we are not in a position to assert positively that every system of coordinates must conform to a fundamental principle; the essence of the gravitation theory being that the gravitational effect of matter has a decisive influence on the measure of the line element, whereby the Riemann curvature tensor attains definite values, *i.e.*, the gravitational field does not admit of path transformation. Accordingly, the curvature tensor of the world of real Nature, and the arbitrary character in the choice of the fundamental magnitudes $g\mu\nu$, appear to be limited. Therefore every conceivable system of coordinates may not be introduced into the world but only such as admit of the curvature effect. The author goes further than Weyl, who admits that only such alterations of the two fundamental forms are admissible as comply with the metrics of the deformation, and attacks the unlimited arbitrary character of the gauge idea itself. He asserts that the last word has not been said with respect to the Einstein theory of gravitation, since the experimental confirmation of the perihelion motion and the curvature of the light-rays are consequences of the hypothesis for the spherical symmetrical ease, and independent of the assumption of a scalar or tensor potential. The author shows that the field laws must possess a general covariant form with respect to coordinates and gauge, but that of all possibilities only those are realised which are compatible with his assumption of the changes in the space-time manifoldness by electrons—namely, the element rotation and the distortion of the coordinate system. This assertion must naturally be derivable from the hypothesis of the world-function. Part I of the paper considers

the non-integrability of the distance transfer as a consequence of the elementary rotation. The cases of 2, 3 and 4-dimensions are investigated. Part II deals with the world-function.

The paper is mathematical throughout. H. H. Ho.

19. *The Field Equations for the Gravitation and Electricity within Matter.* **E. Reichenbächer.** (Ann. d. Physik, 63. 2. pp. 115–144, Sept. 28, 1920.)—The present paper contains a further extension of the investigation of the comparison between the Weyl theory of electromagnetism and that proposed by the author. Important conclusions are derived, and the opinion expressed that there is essential agreement between the two theories. Section I considers gravitation. So many similarities exist between gauge and distortion, that the author was led at first to consider them as identical. Mie had also held that a scalar gravitational potential could only be defined as a gauge, but the author now shows that only those are admissible which conform to the time conditions in the static gravitational system. Section II deals with electro-magnetism. For the case of spherical symmetry only a scalar ϵ is permitted, while the scalar λ corresponding to the permeability must disappear. The author assumes, however, that its value is not zero and becomes unity in the limiting case; he then deduces that fields of exact spherical symmetry do not exist. He is thereby led to an atomistic structure for electricity. The mathematical results are summarised as follows:—The field equation for gravitation, K = 2 div grad A, has been given the form which renders it gauge invariant, namely: F = 2 div grad A $+ 2g^{\mu\nu}\partial A/\partial x^{\mu} \cdot \phi_{\nu}$. In addition to the electromagnetic potential ϕ, a supplementary potential ψ has been invoked,

$$\psi_{\mu} = (2\phi_{\kappa} f^{\kappa\lambda} f_{\mu\lambda} - f^2 \cdot \phi_{\mu}) \cdot [f^4 - ff^*)^2]^{-1/2},$$

and the scalars ϵ and λ defined by its aid:—

$$\text{Div } \phi + \tfrac{1}{2}(\phi_{\nu}\phi^{\nu}) + \tfrac{1}{2}(\psi_{\nu}\psi^{\nu}) = \kappa/\epsilon(1 + \epsilon\lambda),$$
$$\text{Div } \psi + (\phi_{\nu}\psi^{\nu}) = \kappa/\epsilon\,(1 - \epsilon\lambda).$$

These are then introduced into the equation, and have the physical significance of dielectricity and permeability. The electric field equations are next derived, and show clearly the analysis into convection and conduction currents.

The paper is mathematical throughout. H. H. Ho.

20. *The Rigid Body.* **H. Dingler.** (Phys. Zeits. 21. pp. 487–492, Sept. 15, 1920.)—This important problem presented itself to earlier scientific activity as purely experimental—namely: How is the rigid body actually constituted which conforms to the definition? In 1911 the present author put forward the opinion, based on his investigations into the connection between theory and experience in the exact sciences, that the rigid body may be defined and constructed from the laws of Euclidean geometry, bodies being investigated which correspond as far as possible to these laws (theory of exhaustion). This paper contains a critical discussion of the rigid body for the purpose of obtaining data for deciding between the two opposed theories. Two circumstances have hindered the solution of the problem, namely, that about four different principles are involved, and that the whole process has never

been considered in a single age. Four definitions are reviewed, viz., The body which only exhibits spacial changes of shape and size; the hard body; the unalterable body; the body as defined by the laws of Euclidean geometry. The derivation of the scientific rigid body is next discussed at great length.

The paper is philosophical throughout. H. H. Ho.

21. *Atomic Arrangement in Crystals.* **W. L. Bragg.** (Phil. Mag. 40. pp. 169–189, Aug., 1920.)—In many crystals of simple structure, such as diamond or NaCl, the atoms cannot be displaced without destroying the crystal symmetry, which accordingly completely defines them; but in others one or more parameters are required for complete determination, *e.g.*, one to fix the positions of the S atom in iron pyrites, FeS_2, while to determine the place of the oxygen atom in the ruby, Al_2O_3, requires two parameters, and in quartz SiO_2 four are requisite. Certain empirical relations, which hold between the distances separating atoms from their nearest neighbours in the simpler crystalline structures, and which the author has found of service in the analysis of complex crystal forms, are here dealt with, and their physical significance discussed, particularly in relation to the Lewis and Langmuir theories of atomic structure. These relations may be simply expressed by regarding a crystal as an assemblage of close-packed spheres the centres of which coincide with those of the atoms. It is then shown that, within certain limits, it is possible to assign to the sphere representing the atom of any element a constant diameter characteristic of that element. The distance between the centres of two adjacent atoms is found to be expressed as the sum of two constants, represented by the radii of the corresponding spheres. The molecular volume of a compound generally differs widely from the sum of the molecular volumes of its components, but the additive law is shown to hold with considerable accuracy for the atomic distances. The apparent variations in the contribution of any particular element to the molecular volume of compounds are explained by differences in crystalline structure, and not by variation in the space occupied by the atoms. In analysing complex crystal structures, various atomic arrangements have to be tried to explain the intensities of the reflected spectra, and it is shown that two atoms must not be placed closer than the sum of the radii of the spheres representing them. This greatly facilitates the determination of the parameters, which are confined to a much more limited range. The radii of the "atomic domains" are tabulated for a number of crystals and for their component elements, measured in Ångström units. Arranging the elements in the order of their Atomic Numbers taken as abscissæ, while the ordinates represent the diameters of the Atomic Domains, it is found that their free extremities lie in a curve resembling Meyer's curve of atomic volumes. The alkali metals head each period with the greatest diameter, followed by the alkaline earths. The diameter decreases steadily as the atomic weight increases, reaching a minimum for the electro-negative elements at the end of the period, *i.e.*, the periodic relation between the atomic volumes indicated by Meyer's curve can be extended to the compounds of the atoms. Photographic illustrations of crystal models formed of close-packed spheres are given.

The principal features of the Lewis-Langmuir theory are recapitulated, and it is shown how the theory accounts very simply for the

empirical relations arrived at. It is noted that the large diameters assigned to the electropositive elements as compared with those of the electro-negative elements do not, on this theory, imply a corresponding difference in the dimensions of the atomic structure. They merely express the fact that the former do not share electrons with adjacent atoms, but are always surrounded by complete stable shells. The repulsion between these outer shells and the shells of adjacent atoms keeps the atoms farther apart so that they appear to occupy a large space in the crystal structure. The *diameters of the outer electron shells* of the inert gases appear to be:—For Neon, 1·30 Å.; for Argon, 2·05 Å.; for Krypton, 2·35 Å.; for Xenon, 2·70 Å. The crystal of an electropositive element consists of an assemblage of positively-charged ions held together by electrons free to move in the structure under the action of E.M.F. The author suggests that the scheme of empirical relations here formulated may help in the investigation of the complex crystalline forms in which the atoms hold electrons in common, such as nitrates, chlorates, bromates, sulphates and selenates. The conception of the atoms as close-packed spheres limits the number of possible arrangements, and may assist in determining the structure of crystals such as quartz, sulphur, and the alkaline sulphates, for which the dimensions of the lattice are known, but which have so far proved too complicated for complete analysis.

G. W. DE T.

22. *Probability Determinations of Movements of Gas Molecules.* **F. Y. Edgeworth.** (Phil. Mag. 40. pp. 249–272, Sept., 1920.)—This is an attempt to vary, in the hope of elucidating, some arguments which the kinetic theory of gases derives from the Probability Calculus. A. Suppose an immense number of short, perfectly elastic, smooth, cylindrical pistons of equal size but two varieties of density, the two sets equally numerous, moving in a smooth, long, straight, horizontal groove, terminated at each end by a perfectly elastic barrier. The pistons are to be supposed capable of passing each other, being, say, side-tracked after collision and guided by smooth devious paths to be replaced without loss of speed at a new point on the main line. This conception of tethered corpuscles may bear on the molecular vibrations within a solid. The ultimate speed distribution is then investigated:—(1) by Laplace's method (used with reference to averages of observations): (2) by means of Boltzmann's H theorem: (3) by a less complete method (as used by Watson, *Kinetic Theory of Gases*, § 14 *et seq.*) which shows only that the normal distribution is sufficient, but not that it is necessary, for stability. This proof has usually been completed by aid of the H theorem. The error theory of Laplace is here suggested as an alternative complement. The author calls attention to an instance in his own argument of what has been called *a priori*, or *unverified*, or, after Boole, *intellectual* Probability, viz., it was taken for granted that the appearance, in consequence of collisions, of additional couples with speeds U′ and u', $u' > U'$, within a distance of $(u' - U')\,\Delta t$ from each other, the slower M molecule behind the quicker one, was tantamount to, or attended with, the appearance of additional couples corresponding in all respects to the above description except that the slower body is now the quicker one. He suggests that the underlying assumption might be formulated:—A molecular chaos must present the same appearance, both as to the relative position of molecules and as to their velocities, whether contemplated from above

or below, so that corresponding to couples with M behind *m*, there are, on an average, at any time an equal number of couples in other respects similar, but with M before *m*. The arguments can easily be extended to more than two types of mass. B. The random movements of discs on a plane are dealt with by the same three methods. C. These are then applied to the case of Lagrangian in place of Cartesian coordinates. Here it is pointed out that the procedure (1) is not invalidated by the fact that the generalised momenta are functions of the coordinates which vary between successive collisions, and not constants, as usual in the statement of the law of error. For it is not necessary for the genesis of the normal law that the " constants " in the linear function should be rigorously constant. It suffices that they should be random specimens of a medley, as the author has shown [*Law of Error*, Camb. Phil. Trans. p. 128, 1906] ; and as such the coefficients may here be regarded.

D. Methods (1) and (2) are applied to the more general case of encounters between molecules supposed to come within each other's sphere of influence and to be deflected from their previous path according to some unknown law of repulsion, perhaps preceded by attraction. The third argument in the simple form heretofore adopted is inapplicable to cases in which the coordinates are changed by an encounter, and recourse to Liouville's theorem, commonly introduced at an earlier stage, becomes necessary. In the two latter sections the complex molecules with different coordinates may be said to constitute a *universe*, which may be divided into *genera* and *sub-genera* by successive delimitation by values of the coordinates, such that if the normal law is *very well* fulfilled in the *universe*, it will be *fairly well* fulfilled in the *genera*, and *less well* in the *sub-genera*, and conversely. In conclusion, the author suggests that it would be possible to advance further in other directions—in particular where a field of force occurs—on the lines of arguments (1) and (2), without the aid of Hamiltonian Dynamics, by mere Probabilities. G. W. DE T.

23. *Application of Smoluchowski's Theory to the Alteration with Time in the Number of Particles in an Emulsion.* **P. C. v. Arkel.** (Phys. Zeits. 21. pp. 465–467, Sept. 1, 1920.)—As a result of his study of the molecular statistics of emulsions and their connection with Brownian movement, Smoluchowski [Abs. 358 (1917)] concluded that the formula he deduced was in satisfactory agreement with Svedberg's observations (*Existenz der Moleküle*, p. 148, 1912). The author now shows that such agreement cannot be regarded as adequate if all the relations derived by Smoluchowski are tested by means of the experimental material ; the cause of this divergence probably lies more in the incompleteness of the numerical data than in fault in the theory. T. H. P.

24. *Equation of State for all States of Aggregation and the Law of Action of Molecules.* **L. Schames.** (Zeits. f. Physik, 1. 4. pp. 376–384, 1920.)—The equation of state may be written in general form :

$$v(p + \partial\Phi/\partial v) = \mathrm{T} \cdot 2/3 \cdot \partial\mathrm{L}/\partial\mathrm{T} \cdot \Sigma a_i (v_0/v)^i,$$

where Φ denotes the internal potential energy, L the kinetic energy of the translational movement, and the series included under the sign of summation the repulsion function. The author shows that Φ may be represented as a function of v and considers the possibility of deriving this function theoretically from the electronic structure of the molecules. Further, the alteration of Φ on transition from the isotropic to the anisotropic

state is determined, and the dependency of the function Σa_i on the molecular constitution indicated.

The attraction of dipolar molecules at greater distances apart is inversely proportional to the fourth power of the distance, whereas when they are nearer alternate repulsive and attractive members make themselves felt. For most substances the potential may be expressed as a strongly convergent series with four members. The repulsion of the van der Waals' perfectly hard, elastic spheres is replaced by the electrostatic repulsion of the electronic envelopes.

The anisotropic state is distinguished from the isotropic by the introduction of the member $-\Phi_0$, that is, the energy of orientation, which is equal to the latent heat of fusion at absolute zero. For quadripoles Φ_0 is essentially constant.

The points $p = 0$, $T = 0$, $v = v_0$, and $p = \infty$, $T = \infty$, $v = v_\infty$ are thermally to be regarded as critical points between the isotropic and anisotropic states, but since between these states there is the energy difference of orientation, these points are actually only pseudo-critical. For the isotropic and also the anisotropic state only a single equation of state with virtually the same constant is required. T. H. P.

25. *Direct Measurement of the Thermal Molecular Velocity.* **O. Stern.** (Zeits f. Physik, 2. 1. pp. 49–56, 1920.)—The basis of this method of measuring the translational velocity of molecules is as follows: Suppose a vessel V, in which the highest vacuum is maintained, to contain a smaller gas-filled vessel G with a small hole L in its wall. The gas molecules pass through this hole in straight lines into the empty space V with the velocity corresponding with the temperature in G. If a screen with a circular aperture is placed in front of the hole, a narrow pencil of molecular rays passes through the screen and forms a circular spot on a plate P at a distance from the screen. If now the whole apparatus is rotated rapidly about an axis perpendicular to the molecular rays, the spot on P will become displaced in a direction opposite to that of rotation, since the molecules require a certain time to pass from L to P, and during this time P has moved forward through a small distance. The magnitude of this distance is readily calculated from the dimensions of the apparatus, the velocity of rotation and the molecular velocity of the gas in G.

Velocity of Silver-Vapour Molecules.—An apparatus has been constructed on these lines and the velocity of the molecules of silver vapour measured, the results agreeing with the theoretical value.

New Method of Determining Atomic Weights.—The method also serves as a new method for determining atomic or molecular weights. For instance, the results obtained with silver show that silver vapour is monatomic, since, if the silver molecule were di- or n-atomic, the deviation would have been $\sqrt{(2)}$ or $\sqrt{(n)}$ times as great as is actually found. It is proposed to apply the method to measure the molecular weight of carbon vapour. T. H. P.

26. *Analysis of Cloud Distribution at Aberdeen, 1916–1918.* **G. A. Clarke.** (Meteorolog. Office, London, Prof. Notes No. 9. pp. 142–147, 1920.)—The cloud distribution is analysed from the point of view of aerial navigation. Cloud observations are taken at Aberdeen at 7h., 9h., 13h., 15h., 18h., 21h., and to each day is assigned in addition a "cloud characteristic" indicating the kind of cloud which predominated, the

lowest type taking precedence over higher ones if covering 4/10 of the sky or more. The day is "clear" if on the average the total amount of sky covered is less than 4/10, while certain days of very mixed or rapidly changing cloud are classed as "various." Taking Cumulus and Cumulo-Nimbus together, they are found to give the most frequent skies, 23 % of the total, while other low clouds are numerous. Alto-stratus skies are twice as frequent as Alto-cumulus, but Cirro-stratus and Cirro-cumulus skies are of equal frequency. Using the average heights of the various types together with the "cloud characteristic," 15 % of days are seen to be cloud-free below 15,000 ft., 26 % below 7000 ft., 69 % below 3000 ft., while the remaining 31 % of days have cloud predominating below 3000 ft. Seasonal distribution is discussed. The frequency of Cumulus and Cumulo-nimbus taken together is found to be greatest in April, and there are secondary maxima in mid-summer and Sept. Air conditions should be most bumpy at these periods. Strato-cumulus skies are more common in winter than in summer, and there are indications that skies well covered with intermediate and higher clouds are also more frequent in winter, but the observations depend on the presence or absence of lower cloud. M. A. G.

27. *The Nature of Sleet and How it is Formed.* **C. F. Brooks.** (Monthly Weather Rev. 48. pp. 69–72, Feb., 1920.)—Whereas in current practice in the United States, *sleet* is that form of precipitation which is not snow, rain, or hail, an attempt to make a detailed descriptive and genetic definition seems advisable, and 30 cases of sleet are analysed as a basis:—

Sleet, a rattling type of ice precipitation formed in the free air, has the following characteristics: *Size*, smallest dimensions of largest pieces less than 6 mm. (¼ inch); *form*, angular, irregular, or nearly spherical; *structure*, non-granular ice, part or all of which is cloudy or bubbly (except in extremely small drops), not more than one clear layer.

A sleet particle may be (1) a snowflake partly melted and refrozen, (2) a frozen raindrop, or (3) [*Graupel*] a frozen combination of snowflake, and raindrop or liquid (not undercooled) cloud droplets.

A generalised vertical section of sleet weather shows sleet as occurring usually with a cloud from which snow is falling through a stratum of air having a temperature above freezing and into air with a temperature below freezing. Author.

28. *Temperature, etc., on Spitzbergen.* **A. Wagner.** (Akad. Wiss. Wien, Ber. 128. 2a. pp. 709–758, 1919.)—An analysis of the five years' continuous records obtained in the Norwegian meteorological station at Green Harbour, 1912 to 1917. The discussion refers to previous series of observations since 1872 and particularly to the records of 1912 of the German Observatory in Advents Bay, which was later transferred to Ebeltofthafen in Cross Bay. There were at Advents Bay two high-level stations, situated 400 and 1000 m. above sea-level in summer, and at 200 and 400 m. in winter; a report on the balloon and kite observations at Ebeltoft has been published by G. Rempp and A. Wagner. These latter observations are interesting with respect to the frequent inrushes of horizontal and vertical cold and warm air-currents observed on Spitzbergen. Advents Bay and Green Harbour lie 30 km. apart, both in bays of the Eisfjord which penetrates from the west coast 65 km. E.N.E. into the island, Green Harbour being the first bay nearest the sea; the station

is 7 m. above sea-level and is joined to the radio-telegraphic station. Advents Bay is nearer the colder east coast. Special references are made to Ficker's Temperature Fluctuations in Russia and Northern Asia [see Abs. 273 and 439 (1912)]. The annual mean for Green Harbour is $-9{\cdot}3°$ C.; February, with a monthly mean of $-21{\cdot}6°$, is the coldest, July $+5{\cdot}0°$ the warmest month. The interdiurnal changes are very strong in winter; the temperature may change by 16 deg. in 24 hours (21·6 cases, against 19·3 in Siberia); temperatures above 0° occur in all seasons. In the short summer the temperature is very steady, changes exceeding 2 deg. in 24 hours occurring only once in June; the July temperature fluctuated only between 5° and 4° in the 5 years. As regards the intense cold and warm waves, temperature and air-pressure change in the opposite sense, as in Siberia (Ficker); warm waves lead to cloudy rainy weather, cold waves to clear radiation skies. The semi-diurnal temperature change goes parallel with the barometer in winter, probably because the barometer corresponds to the regular change in the wind direction, from the heights down or from the sea, *i.e.*, upwards; the temperature inversion near the ground is generally marked. The diurnal amplitudes are: spring 4·3, summer 2·6, autumn 0·7 deg. As regards the two stations, Green Harbour and Advents Bay, there is very good agreement in temperature during the summer. In winter Green Harbour has both lower monthly means and lower minima, probably on account of the more pronounced inversion near the ground, and because the winds are much feebler there than in Advents Bay. In Green Harbour the daily temperature may be 17 deg. below that of Advents Bay; such days are calm in the former, stormy in the latter place. The maximum and minimum temperatures recorded at Green Harbour during the 5 years are: $+13{\cdot}4°$ (July 21, 1913) and $-45{\cdot}0°$ (Jan. 5, 1916). During the aperiodic waves the temperature rise or fall may last 3 days, the means being 1·5 days for rising and 1·6 days for falling temperature. It is pointed out that the level is important for temperature observation on the ice, on board or on land in Arctic zones, especially during the winter; Wegener observed at Danmarkshaven higher temperatures (up to 8 deg.) in the lookout than 31 m. below at the base. H. B.

29 *Preliminary Steps in the Making of Free-Air Pressure and Wind Charts.* **C. L. Meisinger.** (Monthly Weather Rev. 48. pp. 251–263, May, 1920. Two papers read before the Am. Meteorolog Soc., April, 1920.)—The most accurate forecasts of winds at moderate elevations over wide areas can be made only when we have isobaric and wind charts for those levels. One of the most important steps in the making of such charts is the securing of accurate data on the mean temperature of the air column between the station and a given level in the free air. To this end, such information, obtained by kites at Mount Weather (Va.), Drexel (Nebr.), and Ellendale (N. Dak.,) has been classified by months for each of the eight recorded wind directions at the surface. The surface wind direction has been used as an index to determine whether such local phenomena can be used as a guide to conditions aloft. The final values which were obtained from a study of the data represent the differences in degrees, centigrade, between the mean temperature of the air column and the surface temperature. It was found, in general, that in winter, with southerly winds, the air column has a higher mean temperature than the surface; that in summer, with northerly winds, the air column has

a temperature below that of the surface. These effects are due primarily to the seasonal variation of surface temperature. The amplitude of the values was much greater at the inland stations, Ellendale and Drexel, than at Mount Weather, near the coast. Aside from the geographical contrasts, the difference between the surface temperature and that of the air column to a height of 1 or 2 km. depends, so far as the surface factor is concerned, mostly on the season; and, so far as the temperatures aloft are involved, upon the wind direction.

A statistical study of the errors which may be carried into the reductions of pressure to levels in the free air as a result of the errors in the temperature argument, leads to the gratifying result that the values by which the surface temperature is corrected to obtain the mean temperature of the air column, will not, in general, be in error by more than 1·5 deg. C., which, even with long air columns, is not sufficiently large to produce large errors in the pressure. For air columns 1000 m. in length, when the conditions are, for example, $\theta = 0°$ C., and B_0 (station pressure) = 1000 mb., the study shows that the probable variation of a given value in temperature units will yield a probable variation in pressure units of about $\pm 0{\cdot}5$ mb.; and, under the same conditions, with a 2000-m. air column about $\pm 1{\cdot}3$ mb. These errors are very small indeed. AUTHOR.

30. *High Free-Air Wind Velocities observed on December* 16 *and* 17, 1919. **W. R. Gregg.** (Monthly Weather Rev. 47. pp. 853–854, Dec., 1919.)—Over the northern part of the United States east of the Rocky Mountains the winds at and near the surface were from varying directions and ranged from 0 to 10 m. per sec. Kite and pilot-balloon ascents at many stations showed that at higher levels a uniform W.N.W. to N.W. wind prevailed, the speed increasing very considerably with height and reaching at 7·2 km. above Lansing, Mich., the value 83 m. per sec. Kite ascents showed that a strong south to north surface temperature gradient, temperature decreasing northwards, persisted at least up to the 2·5 km. level, and this accounted for the increase of wind with height. It is remarked that in the middle Western States cirrus is practically never observed to move from the east, except in the summer part of the year, the winter temperature distribution being such as to prevent any easterly wind in the upper layers of the troposphere. M. A. G.

31. *Prevailing Winds of the North Pacific Coast.* **A. E. Caswell.** (Monthly Weather Rev. 47. pp. 855–856, Dec., 1919.)—By considering the prevailing winds for each month at stations down the Pacific Coast of N. America, the seasonal variation of the latitude in which the centre of the Pacific belt of high pressure crosses the coast line is deduced. From Nov. to Jan. it crosses in latitude 40° N. and from April to Aug. in lat. 46° N., the transition between the two positions being somewhat rapid. Similar information is obtained concerning the northern mean low-pressure belt. The results are said to agree with the mean isobaric charts of the U.S. Weather Bureau. Application of the method to the Mississippi Valley is unsuccessful owing to the effect of topography on the prevailing winds inland. M. A. G.

32. *Possibilities of the Rocket in Weather Forecasting.* **R. H. Goddard.** (Nat. Acad. Sci., Proc. 6. pp. 493–495, Aug., 1920.)—The author considers

the possible application of his rocket method of reaching extreme altitudes [see Abs. 1364 (1920)] to the problem of obtaining meteorological observations, for forecasting purposes, from the moderate height of about 10 km. The rocket carrying the instruments must occupy as little time as is practicable in ascending and descending, but must remain for an appreciable interval (1 to 5 mins.) at or about the 10-km. level. The propulsive force is practically constant and the consequent absence of jar makes the rocket suited for the raising of apparatus, while to maintain the 10-km. level for a desired interval a small rubber balloon and steel sphere of compressed hydrogen would be carried, the hydrogen being released into the balloon when the rocket had reached its upper limit. At the end of a predetermined interval the balloon would be released from the rocket and a parachute device would ensure any desired rate of descent. The time to reach the 10-km. level should be of the order of 20 secs. As an example, with gases ejected at a speed of 5500 ft. per sec., a rocket weighing of the order of 11 lbs. initially and 6 lbs. at the highest point, would be necessary to send instruments weighing 1 lb. to the 10-km. level. M. A. G.

33. *Exposed Steel Temperatures in the Tropics.* **H. G. Cornthwaite.** (Monthly Weather Rev. 48. pp. 403–404, July, 1920. Eng. News-Record, 85. p. 803, Oct. 21, 1920.)—The experiments were made at Balboa Heights in the Canal Zone, in the month of April on days when the midday sun was overhead. Steel blocks were exposed to the sun and shielded from the wind, and the temperature of the metal was measured at intervals of 15 or 30 minutes by a thermometer immersed in mercury contained in a well bored in the steel. The highest temperature recorded was 133° F. at 3.30 p.m. April 26, and 140° F. is the highest temperature likely to be reached there under natural conditions. The experiments were extended to blocks of steel painted black, green, red, and white, and the temperatures ranged themselves in this order, the black steel block attaining the highest and differing on one occasion by as much as 20 deg. F. from the white steel. The red steel temperatures were only slightly above the white, while the green steel appeared to absorb nearly as much heat as the black. M. A. G.

34. *Meteorological Observations of a Bombing Pilot in France.* **T. R. Reed.** (Monthly Weather Rev. 48. pp. 216–217; Disc., 217, April, 1920. Paper read before the Am. Meteorolog. Soc., Washington.)—Describes the "bumpiness" experienced when flying. On days of cumulus cloud smooth flying is usually found above the cloud summits: some rare exceptions were, however, noted in which the air was bumpy above as well as below, and details are given of such a case occurring in the front of an advancing depression. M. A. G.

35. *Kite Flight in the Centre of a Deep Area of Low Pressure.* **V. E. Jakl.** (Monthly Weather Rev. 48. pp. 198–200, April, 1920.)—A kite ascent up to about 1·5 km. was obtained at Drexel on the morning of March 28, 1920, near the centre of a deep depression. Pressure at the surface reached its lowest at the commencement of the ascent and remained practically stationary, with light southerly surface winds, throughout the flight, which lasted two hours. After a further two hours pressure began to rise abruptly and a N.W. gale set in. Comparing the observations during

ascent with those during descent and both with those of the preceding day, it is seen (1) that in front of the depression near the centre there was a decrease and veer of the wind with height, the surface southerly current becoming westerly above, (2) that the veer spread progressively downwards towards the surface, (3) that the veering wind was accompanied and preceded by a fall in temperature which was in all probability going on simultaneously with the rising temperature near the surface in the strong southerly current in front of the depression. It is thought that this last tendency towards instability might later have become more marked and have accounted for the tornadoes which occurred farther east the next day. M. A. G.

36. *Kansas Tornadoes.* **S. D. Flora.** (Monthly Weather Rev. 47. pp. 447–448, July, 1919.)—In spite of popular opinion, the available data do not indicate that Kansas is, area considered, more liable to visitations by tornadoes than other States in the same part of the country. During 33 years 302 tornadoes have been reported in Kansas. Of these 9 % have occurred in the western third of the State, 41 % in the middle third, and 50 % in the eastern third. They are distributed over every month of the year except Jan. and Dec., but 50 % of those recorded occurred in May and June. They may occur at any hour of the day, but usually in the late afternoon. The S.E. quadrant of a well-developed depression is the usual place of occurrence, but they have been reported in the N.E. and S.W. quadrants. It is not uncommon for two of the characteristic pendent clouds to be seen at the same time and as many as eight have been observed at once. Two may combine to form a more violent one. They usually cross the country from S.W. at about 40 miles/hr. and the track seems almost entirely independent of topography. Nine photographs of tornado clouds are reproduced. M. A. G.

37. *Temperature Inversions near the Surface in the Antarctic.* **J. Rouch.** (Comptes Rendus, 171. pp. 498–500, Sept. 6, 1920.)—The observations discussed were made in lat. 65° 10′ S., long. 66° 34′ W. of Paris, with two thermometers, one 2 m. above sea-level and the other 35 m. above sea-level on a hill 300 m. distant. The observations were taken simultaneously at 10h. each day, from March to Oct., 202 being secured. The mean difference between the readings of the two thermometers is +0·04 deg. where the + sign indicates an inversion. Considering the months separately, the mean difference ranges from + 0·45 deg. in May to − 0·52 deg. in Oct. Of the 202 pairs of observations 45 show inversions and 48 an isothermal condition. The greatest inversion is 5·3 deg. on July 1. The greatest negative difference is − 1·5 deg. on Oct. 7. An analysis of observations of the other elements, in conjunction with temperature, shows that the inversions are associated chiefly with calms or light winds and tend to be greater the lower the temperature and the smaller the cloud amount. Further, they are most frequent with pressure above the normal. Of 23 observations with mist there are 5 inversions, while of 58 observations with snow only in one case was there an inversion (+ 0·2 deg.). M. A. G.

38. *Comparison of Snow-board and Rain-Gauge-Can Measurements of Snowfall.* **R. E. Horton.** (Monthly Weather Rev. 48. pp. 88–89, Feb., 1920.)—The author's snow-board consists of a sheet of white beaver

board, about 16 in. square, on which a layer of cotton flannel is tacked, nap uppermost, to simulate the snow surface on which the board is exposed and to prevent the melting of the snow caught. In the heavier snows the board catches more snow than the can, the water-equivalent being fairly consistently in excess by about 16 %. With very light snow flurries it may register the same or less than the can and give deficient results. M. A. G.

39. *Microseisms.* **J. J. Shaw.** (Nature, 106. pp. 348–350, Nov. 11, 1920.)—For the last twenty years these small "earth-tides." have been known to seismologists. The wave period ranges between 4 and 8 secs., the amplitude between $\frac{1}{50000}$ and $\frac{1}{2000}$ of an inch, and the wave-length between 8 and 16 miles. They have been attributed to air tremors, and to the rocking of buildings by the wind or of the ground by the same agency through the medium of trees, but they are now known to be pure earth movements travelling over long distances, easily measured and recorded, but of unknown origin. Comparison between traces from instruments at considerable distances apart is difficult, as identification of such small movements is generally impossible. The author has worked with two seismographs under as nearly as possible identical conditions, only 60 feet apart. The first similarity of the traces negatives the air tremor hypothesis. Altering the sensitiveness to "tilt" of one of the instruments, which would quite alter the scale of an ordinary earthquake makes no difference to the microseisms, which would therefore seem mainly horizontal movements, and yet instruments of the vertical form register them quite freely.

Next stations two miles apart were utilised with special precautions given in detail, and the identification of waves presented no difficulty, but improvement was necessary in the accuracy of the time scaling.

In general the wave period increased with the amplitude, and that with the daily movement of the air, but the meteorological conditions had no effect on the duration of the waves, which nearly always came from the north. The "distant" station was in a "dug-out" in a direction 17° W. of N., and the waves always reached it first by about 0·8 sec.

The next projected stage is to have three stations at the corners of a 10-mile triangle with improved timing arrangements. W. W. B.

40. *Tidal Friction.* **H. Jeffreys.** (Roy. Soc., Phil. Trans. 221. pp. 239–264, Nov. 5, 1920).—The tidal currents in mid-ocean are insufficient to give any important dissipitation of energy. After making some theoretical postulates as to the estimation of velocities in shallow seas, all the important shallow seas of the world are examined. The amount of dissipitation so obtained is critically considered, and the general conclusion reached that the hypothesis that the secular acceleration of the moon is due to the dissipitation of energy in the tides of shallow coastal regions, seems capable of satisfying all the quantitative demands upon it. In an appendix it is shown that the obliquity of the ecliptic is diminishing, though there is no reason to believe that there has been any appreciable change in historic times. [See Abs. 311, 1045 (1920).] W. A. R.

41. *The Aurora of March* 22–25, 1920, *and Associated Displays.* **C. F. Brooks** and **H. Lyman.** (Monthly Weather Rev. 48. pp. 379–392,

July, 1920. Presented before the Am. Meteorolog. Soc. Washington, April, 1920.)—A disturbed area marked by a group of sun-spots stretching more than a quarter of the way across the face of the sun bombarded the earth with such an abundance of electrified atoms that it caused an intense magnetic storm and an extraordinarily active and brilliant aurora, lasting for 20 hours and followed by 3 days of lesser magnetic and auroral activity. The beginning of the aurora was observed at Tatoosh Island, Washington, and in Australia practically simultaneously; then it became visible at dusk successively around the world until the last of its brilliance was seen towards dawn in the north-western United States.

The numerous reports show not only that the periods of greatest brilliance and max. magnetic activity were simultaneous throughout the world, but also that the general aspect of the display as a whole was similar. The local differences depended largely on the positions of the observers relative to the great series of auroral curtains. Great activity, some brilliant colours, especially crimson, and great vibrations of the whole display were characteristic features.

Some 100 reports received from parts of eastern North America have made it possible to map the actual locations of the brilliant auroral curtains at particular times, and thus to picture what might be called the geography of the aurora.

Auroræ and magnetic disturbances occurred in mid-February, mid-April and mid-May, during the preceding and following presentations of the same active region on the sun, as it rotated.

This aurora ranks among the greatest five world-wide displays of the past 5 (or, in fact, 11) years, embracing the recent unusual sun-spot maximum. In many places this aurora was the most brilliant one seen in this country. AUTHORS.

42. *Colour of the Night Sky.* **Rayleigh.** (Nature, 106. p. 8, Sept. 2, 1920.)—Both visual and photographic evidence is obtained that the light of the clear night sky is much yellower than that of the clear, or even cloudy, sky at twilight. The author has previously found a comparative absence of polarisation in the night sky light, and this supports the present result in pointing to the conclusion that this light is not due to sunlight scattered by rarefied gases beyond the earth's shadow.

The visual observations were made by mounting a yellow and a blue gelatine film edge to edge at the end of a pasteboard tube which was pointed at the sky. For the photographic observations an Ilford panchromatic plate was exposed under a yellow and also under a dense blue filter. M. A. G.

43. *A Prominence with Great Radial Velocity.* **V. Burson.** (Comptes Rendus, 171. pp. 570–571, Sept. 27, 1920.)—In the course of routine solar work at Meudon it is rare for a prominence to show on the K_3 or low-level calcium spectrogram, as such objects belong to the high-level K_1 spectrogram. The present, Sept. 8, is a case when the K_3 photograph showed a detached portion of prominence, and the fact leads to an inference of a radial velocity of at least 100 km./sec. The observer confirmed this by opening the 1-mm. slit to 2 mm. and 3 mm., one photograph indicating an approach of 132 km./sec., and another, half an hour later, a recession of 70 km./sec. An hour later still, weak movements in both directions were shown. The prominence appeared

to be connected with a large patch of faculæ near the W. limb. This region had shown considerable activity since it appeared on the E. limb on Aug. 28. W. W. B.

44. *Origin of Periodic Comets.* **H. N. Russell.** (Astron. J. 33. pp. 49–61, Sept. 15, 1920.)—The circumstances of closest possible approach to the major planets have been computed for all comets known to have periods less than 2000 years. 42 of these have periods exceeding 10 years and have high inclinations; few of them pass near planetary orbits, and the number with periods between given limits is nearly proportional to the cube roots of the limiting periods. The distribution of distances of closest approach to planetary orbits agrees quite well with a computed random distribution. Only two of these comets come close enough to a planetary orbit to make a capture theory possible. These are 1854 IV (1089 years) by Jupiter and 1886 V (263 years) by Saturn.

The author compares various suggestions that have been made, but his general conclusion is that there have been no captures since a remote past, and that the orbits have been greatly shifted by perturbations. Theoretically he thinks it probable that Jupiter has captured the great majority and Saturn the rest. There is some evidence of possible capture by Uranus, but none by Neptune. The conventional idea of "families," sorted out by aphelion distances is, he thinks, without secure foundation.

The comets of short period are on a different footing, and their comparatively large number is probably due to disruption by the action of Jupiter. W. W. B.

45. *Sampson's Tables of Jupiter's Satellites. Comparison.* **R. Innes.** (Union Obs. S. Africa, Circ. No. 50. pp. 70–71, July 29, 1920.)—Observations of eclipses of the first three satellites of Jupiter made at Johannesburg during the last 12 oppositions are compared with Sampson's tables. The times tabulated are disappearance and reappearance, the half difference (checking the duration), and the half sum (checking the longitudes). These suggest the need of an increase in the adopted value of the inclination of Jupiter's equator to his orbit, and a possible negative correction to the ascending node. For all three satellites the corrections to mean longitude are negative. A comparison for 1900 epoch is given between the Johannesburg observations and the three sets of tables, of Sampson, de Sitter, and Damoiseau. More series of regular observations of these phenomena are requested from different observatories to enable definite corrections to be adopted to the numerical theory of the satellites. W. W. B.

46. *Stock-taking of Variable Stars.* **F. de Roy.** (Observatory, No. 556. pp. 323–327, Sept., 1920.)—This is a review of the first volume of the *History and Literature* of the variable stars, now at last issued by the Astronomische Gesellschaft. It comprises 838 stars in the first 14 hours of R.A. A second similar volume will contain stars for the remaining 10 hours of R.A., with cluster variables, novæ, and stars yet unnamed but probably variable. A third volume is to contain the catalogue proper, with newest elements and auxiliary tables. The work covers much the same ground as Harvard volumes on the subject, but

is to some extent complementary, and contains much detail not elsewhere collected. To save expense, light-curves are not given. The responsibility for full accounts of the separate stars has been shared very unequally among eleven astronomers, of whom, however, Müller provides more than half the total number, including most of the longest notices.

Of the 838 stars in the volume, 312 are still unknown as regards the character of the variation, and 83 others are classed as irregular, leaving 437 with definite elements, only 121 of which are new.

The reviewer quotes details of some of the more striking stars, including Mira Ceti and η Geminorum, and also of some of the fainter stars, R Boötis, R Lynci, S Orionis, R Tauri, T Camelopardi, R Geminorum, U Canis Min., S Cancri, W Cancri, R Ursæ Maj., R Canum Ven., and R R Boötis. The Cepheids and other short-period variables receive less attention, and a few errors are pointed out. W. W. B.

47. *Secular Parallax of Stars of Different Magnitude and Spectral Classes.* (Publ. No. 29. Astron. Lab., Groningen. Review by J. C. Kapteyn in : Nature, 150. pp. 838–839, Aug. 26, 1920.)—This summarises the new material now available since the author took up the subject of stellar distribution. He considers the time now ripe for a fresh investigation of secular parallax of stars of different magnitudes and spectral classes, the secular parallax being defined as the angle subtended at the star by the unforeshortened annual motion of the sun. Thus annual parallax = sec. par. $\times$ 0·243. He finds values for variation of parallax with galactic latitude, increasing from the galactic plane to the pole. He obtains a very small discordance between his determination of the solar apex from stars of different magnitudes, and attributes the larger discordances generally found to imperfect elimination of magnitude equation. He considers it quite as important to separate different spectral types in his investigation as to separate the elephant and the flea in a statistical study of the animal kingdom. He gives a table of mean secular parallax for different Harvard magnitudes and different spectral types, as follows :—

Maj.	B Stars.	A Stars.	F Stars.	G Stars.	K Stars.	M Stars.
1·0	0·138 "	0·253 "	0·591 "	0·627 "	0·362 "	0·172 "
2·0	0·0921	0·170	0·392	0·422	0·241	0·116
3·0	0·0622	0·115	0·267	0·285	0·163	0·0786
4·0	0·0422	0·0780	0·182	0·192	0·110	0·0537
5·0	0·0285	0·0526	0·123	0·129	0·0749	0·0361
6·0	0·0192	0·0355	0·0827	0·0876	0·0506	0·0244
7·0	0·0130	0·0240	0·0560	0·0599	0·0342	0·0163
8·0	0·0087	0·0161	0·0379	0·0403	0·0231	0·0108
9·0	0·0059	0·0109	0·0254	0·0271	0·0156	0·0073

From the small values at the foot of the M star column it will be seen that these distant M stars are giants almost equal to the B stars in absolute magnitude, though others of the M stars 17½ magnitudes fainter than the B stars are dwarfs. W. W. B.

48. *Search for Polarisation Effects in Nebulæ.* **W. F. Meyer.** (Lick Observat., Bull. 10. [Circ. No. 328.] pp. 68–78, 1920.)—Twelve nebulæ tested by a photographic method which can easily detect 10 % of plane-polarised light are classified thus:

(1) 5 planetary nebulæ. No polarisation found.
(2) 4 spiral nebulæ. Very small effect shown and so contradictory as to be probably accidental.
(3) 2 extended nebulæ. Orion nebula and its companion. No evidence of polarisation.
(4) Hubble's variable nebula. Not more than 10 % polarised, much less than from the solar corona.

The theory that outlying branches of spirals are shining by light reflected from the central nucleus fails to find support. The method fails unless the reflecting materials are small particles or gas molecules. The idea of stars immersed in the nebular structure cannot be tested by the method, but seems intrinsically improbable for reasons given. W. W. B.

49. *Proper Motion of Two B.D. Stars.* **F. Schlesinger.** (Astron. J. 33. p. 70, Oct. 9, 1920.)—The stars B.D. + 1°·4134 and 4135 are 2′ 42″ apart, visual magnitudes 8·5 and 8·8, spectra KO. The author finds from comparison of the Albany Catalogue with his photographs proper motions of − 0·″023 in R.A. and − 0·″269 in decl. for the first star and − 0·″033 in R.A. and − 0·″267 in decl. for the other. The stars must therefore form a system with common proper motion, though so far apart that their mutual attraction is very small. It is desired to obtain parallaxes and radial velocities of these stars and other similar systems. W. W. B.

50. *Charlier's Critical Surface in Orbit Determination.* **A. Wilkens.** (Astron. Nachr. No. 5067. Nature, 106. p. 356, Nov. 11, 1920.—Abstract.)—Charlier's surface separates those regions in space where the problem of orbit determination from three observations has two solutions from those where there is only one. It is a surface of revolution about the line from the sun to the earth. The author gives tables for laying out the intersection of this surface with the ecliptic. The curve resembles a looped *limaçon*, both loops passing through the earth as a double point, the inner one extending as far as the sun and the outer one 2·7844 times as far. W. W. B.

51. *Interference Methods for Astronomical Measurements.* **A. A. Michelson.** (Nat. Acad. Sci., Proc. 6. pp. 474–475, Aug., 1920.)—This method of measuring close double stars and possibly stellar discs was suggested in 1890, and has now been tried with the Yerkes 40-in. refractor, and also with the 60-in. and 100-in. reflectors at Mt. Wilson. It is found that the quality of the "seeing" is not of such very great importance as it is in visual work. Distances of less than five hundredths of a second of arc are measured to three significant figures, and Anderson's observations of Capella are given, with the deduced elements of the orbital motion. The method is to be further tested at Mt. Wilson with a base of 18 to 20 feet. W. W. B.

52. *Connection of Planetary Nebulæ with Helium Stars.* **H. Ludendorff.** (Astron. Nachr. No. 5065. Nature, 106. p. 254, Oct. 21, 1920. —Abstract.)—Planetary nebulæ show high average radial velocity. Spectroscopically they resemble helium and Wolf-Rayet stars, which have a very low velocity. Keeler's list of 12 nebulæ has been increased by the publication of a list of 96 nebulæ by Campbell and Moore, the mean radial velocity being thus increased from 25 to 30 km./sec. Helium stars are said to have low velocity on account of their great mass. But the planetary nebulæ show evidence of great mass also. Campbell noted spectroscopic evidence of rotation in some cases. Using van Maanen's parallaxes the author finds the masses of four planetary nebulæ, 14, 19, 162, and 28 times the sun's mass. On further examination of the B stars he finds radial velocity to increase with mass, and the same for Wolf-Rayet stars. No explanation of this seeming improbability is given. W. W. B.

53. *On Apparent Displacements of Stars at Solar Eclipse, May* 29, 1919. **F. E. Fournier.** (Comptes Rendus, 171. pp. 501–504, Sept. 13, 1920.)—The author finds a hypothetical value for the velocity of emanations from the sun, and states that if this is equal to that of light for the sun or for a star, they will be visible to us. If the velocity falls lower from any region of the sun, a spot will appear, and similarly if from a star it would become invisible: a subsequent increase to the limit would make the star flash out again. He considers that sun and stars also continually project cosmic matter, which remains invisible though contributing heat when passing through our atmosphere, and also others of electric or magnetic essence, or kathode rays, which have their characteristic effect in the same way. This bombardment, he says, causes the advance of the perihelion of the planetary orbits, only noticeable in the case of Mercury, and also controls the direction of comets' tails. This eruptive force is not constant; hence the variation in appearance of sun-spots and in terrestrial magnetic phenomena, which, he says, are governed not by the sun-spots themselves but by the varying bombardment of which they are a symptom. He thinks that if an all-pervading ether were to disappear gravitation would not be affected, but universal darkness would result. W. W. B.

54. *On Apparent Displacements of Stars at Solar Eclipse, May* 29, 1919. **F. E. Fournier.** (Comptes Rendus, 171. pp. 560–563, Sept. 27, 1920.)—This is a continuation of an earlier paper [see preceding Abs.], dealing with the displacement of rays passing near the sun. He considers the ether itself to be more dense near the sun, and the rays to be bent towards the sun in their passage. On his previous assumption that sun and stars are sending out energy with volcanic explosive force at varying rates, he works out the repulsive force from the sun on each of the planets, finding values for the perturbing acceleration. Defining the effect on Mercury to be unity, he obtains for Venus 0·248, Earth 0·157, Mars 0·277, Jupiter 0·0109, Saturn 0·0135, Uranus, 0·009, and Neptune 0·0055. The Mercury effect, 43″ per century, is much greater than any of the others. W. W. B.

55. *Parallaxes of* 50 *Stars* (2*nd list*) *Determined at Sproul Observatory.* **A. Millar, J. H. Pitman,** and **H. B. Steele.** (Am. Phil. Soc., VOL. XXIV.—A.—1921.

Proc. 59. 2. pp. 85–149, 1920.)—Details are given of the data of observation and reduction in respect of each of the 50 stars, many of them well-known binaries. Of the resulting parallaxes 5 are between $0''\cdot1$ and $0''\cdot15$ and 12 between $0''\cdot05$ and $0''\cdot1$. On the other hand, 12 are less than $0''\cdot01$, the actual range being from $+ 0''\cdot002 \pm 0''\cdot016$ to $+ 0''\cdot146 \pm 0''\cdot014$. W. W. B.

56. *Globular Cluster M. 3. Photometric Investigation.* **H. Shapley** and **H. N. Davis.** (Nat. Acad. Sci., Proc. 6. pp. 486–489, Aug., 1920.)—This forms No. XII of Studies of Magnitude in Star Clusters. After sketching the general purpose of the investigation and mentioning two open clusters (M. 67 and M. 11) and two globular clusters (M. 13 and M. 3), of which fairly complete surveys have been made, the authors confine their attention to the last-named cluster, because its distance is known with greater accuracy, the adopted parallax being $0''\cdot000072$. Stars within $1'\cdot8$ of the centre of the cluster are not included, as they cannot be properly separated from the mass, but excluding a few doubtful ones there remain 750 stars, not fainter than 17th magnitude available for the discussion. Zero magnitude (absolute) corresponds to apparent magnitude 15·72. Curves showing the frequency of absolute photovisual magnitudes of red, yellow, and blue stars separately are given, and these show such marked features that it appears unsafe to base any investigation on the general luminosity curves of clusters. Mean brightness and colour show hardly any dependence on distance from the centre, and the relation between brightness and colour is in agreement with previous results for M. 13. A separate investigation is in hand dealing with the Cepheids in the cluster. The apparent visual magnitude of the cluster is 6·6, showing an absolute magnitude of $-9\cdot1$, or 360,000 times the brightness of the sun. The 750 stars are all "giants" with magnitudes ranging from 1 to $-3\cdot5$. W. W. B.

LIGHT.

57. *Vertical Interferometer.* **A. A. Michelson.** (Nat. Acad. Sci. Proc. 6. pp. 473–474, Aug., 1920.)—For the measurement of very narrow groups of spectrum lines, barely within the resolving power of most spectroscopes, interference methods have a great advantage in their avoidance of instrumental and optical imperfections. It is, however, difficult to ensure the parallelism of the moving mirror, and for this purpose the author uses a vertical interferometer, in which the moving mirror is a thin layer of mercury in an amalgamated trough, the depth of mercury being not more than half a millimetre. Thus tremors are almost eliminated. W. W. B.

58. *New Design of Precision X-ray Spectrometer.* **C. D. Cooksey.** (Phys. Rev. 16. pp. 305–312, Oct., 1920.)—*Principle of the Spectrometer.*—The spectrometer is especially designed to make use of the "*Method of Displacement,*" already published, for the determination of X-ray wave-lengths. This method is briefly described. A detailed description of the spectrometer with a plan and side elevation are given and the processes involved in the adjustment of the spectrometer for precision measurements on X-ray wave-lengths are explained.

Verification of the Fundamental Assumption on which the "Method of Displacement" is based.—The method requires that a portion of the length of a beam of X-rays shall, after reflection, be of constant width. The possibility of this has been previously demonstrated on theoretical grounds. An exploration of the reflected beam for the α_1 line of the K series of silver has been made and the results are found to agree with theory. AUTHOR.

59. *Theory of Polarisation Prisms.* V. **H. Schulz.** (Zeits. Instrumentenk. 40. pp. 180–182, Sept., 1920.)—This paper gives mathematical theory relative to prisms of the Feussner type, consisting of a scalene right-angled glass prism with a plate of some crystal, usually calcite, cemented to the face opposite the right angle. [See Abs. 566 (1920).] A. W.

60. *Microscopy with Ultra-violet Light.* **J. E. Barnard.** (Nature, 106. pp. 378–381, Nov. 8, 1920.)—This paper describes a microscope designed to be used with ultra-violet light. The *apparatus* is in operation in the microscopical department at the National Institute for Medical Research. Objects that show little or no structure by ordinary transmitted light are seen to be highly organised when examined by ultra-violet radiations, and the structure seen is in part dependent on the wave-length of the light used. Objects for examination by this method must be dealt with in the living state, or at least in such a manner that no change takes place in their constitution; hence none of the ordinary methods of mounting can be employed. The *method* is, in fact, its own staining process, differentiation of structure depending on the difference of absorption in the ultra-violet. The organisms or tissues are mounted in any suitable fluid which is transparent to ultra-violet light, and the photograph taken at once. The apparatus is in its essentials the same as that devised by Kohler, though many improvements in points of detail have been devised. The slides used are of fused quartz, with the smallest possible

quantity of gelatine on their surface. Illustrations are given of typical photographs. A. W.

61. *Anomalous Dispersion of Methyl Violet, etc.* **J. E. Verschaffelt** and **R. Crombez.** (Acad. Roy. Belge [Classe des Sciences], Bull. 2. pp. 31–36, Feb. 7, 1920. Nature, 105. pp. 559–560, July 1, 1920.—Abstract.)—The authors divide a glass trough by means of a diagonal partition into two prismatic troughs, one of which is filled with the solution, the other with the solvent alone ; the dispersion of the solvent is eliminated by this method of opposed prisms, as is shown, and the dispersion of the material is directly observed. The source of light was a calcium arc. The indices of refraction of 3 dyes determined in this way are : methyl violet, solvents in two series alcohol and water, wave-length 6712, 6497, 4455, 4227, index 2·52, 2·43, 1·23, 1·45 ; fuchsine, solvent alcohol, wave-length, 6712, 6497, 6170, 5857, 4227, index 2·21, 2·41, 2·63, 2·78, 1·19 ; paranitroso-dimethyl aniline, solvent alcohol, wave-length 6497, 6170, 5857, 5603, 5270, index 1·74, 1·78, 1·81, 1·85, 1·93. In the first two cases the values found are in fairly satisfactory agreement with Pflüger's determinations of the indices of solid prisms of the dyes ; in the third case the figures agree well with those of Wood, who used the same method [Abs. 661 (1899)], referring back to Soret. H. B.

62. *Dispersion of Water and Ethyl Alcohol between 7 and 35 mm. Wave-length : Preliminary Experiments on the Use of still shorter Electric Waves.* **W. Möbius.** (Ann. d. Physik, 62. 4. pp. 293–322, June 17, 1920.)—Study of the dispersion of water and ethyl alcohol for electric waves of 7–35 mm. wave-length gives for the coefficient of absorption k, the absorption index H, and the index of refraction n fairly smooth curves, water showing an absorption band at $\lambda = 22$ mm. and alcohol giving a curve which falls off gradually towards the smaller waves. Measurements were also made with a prism, but the results obtained are less trustworthy, although they mostly lie in the neighbourhood of the curves. Of the values given by other observers, some agree well but others poorly with the curves.

On many of the interference curves employed in the determination of the wave-lengths small waves of $\lambda = 5 - 0{\cdot}1$ mm. were found superposed, these being, partially at least, harmonics of the transmitter. Experiments were begun with the object of isolating these short waves and employing them for dispersion measurements, but more sensitive measuring methods are required. T. H. P.

63. *Method of Accurately Focusing the Image of a Light Source upon the Slit of a Spectrograph.* **G. A. Hemsalech.** (Phil. Mag. 40. pp. 316–317, Sept., 1920.)—The *method* adopted, which has been found very convenient in practice, is the *converse of the usual one*. The slit is illuminated by means of light sent along the axis of the collimator. The slit image formed by a lens at a convenient distance away is then made to coincide with the position of the light source (such as the tips of two sparking electrodes), a small magnifying lens being used to obtain greater accuracy than would be possible with the unaided eye. If the slit image is not coincident with the line joining the electrode tips, a parallax effect will be obtained on moving the eye sideways. *Adjusting Position of Focusing Lens.*—A similar method can be used for adjusting the position of the focusing lens. A. W.

64. *Annealing Temperature of Glass.* **J. T. Littleton** and **E. H. Roberts.** (Optical Soc. of America, J. 4. pp. 224–229, July, 1920.)—Describes a method for determining the annealing temperature of glass on the assumption that for any glass at its annealing temperature the viscosity is the same. The annealing temperature of one glass, used as the standard, was determined by observing the time taken for the strains in a rod to be completely relieved, as observed optically by means of polarised light. The empirical relation found to exist between the time for complete relief of strain, T, and the temperature $t°$ C., was found to be $\log_{10}T = 0{\cdot}0289\ (602 - t)$. Accordingly 550° C. was taken as the annealing temperature for this "standard" glass. A rod of this glass was then twisted by means of a weight hanging over a light pulley whose axis formed a rigid continuation of the glass rod. The rate of twist, observed by means of a mirror attached to the axis of the pulley, was then found when the glass rod was at the annealing temperature. For any other glass the temperature of a similar rod was raised until the rate of twist, with an equal weight on the pulley, was the same. This temperature was then taken as the annealing temperature of the glass under test. J. W. T. W.

65. *Classification of Lenses and Optical Instruments.* **C. W. Frederick.** (Optical Soc. of America, J. 4. pp. 236–238, July, 1920.)—A report of the Standards Committee on Lenses and Optical Instruments, dealing with single lens combinations only. The first section deals with the nomenclature and classification of photographic objectives, telescope objectives (visual) and microscope objectives. The first two groups are classified by aperture ratio, focal length, and field angle, the last by numerical aperture, E.F.L., and working distance. A second section deals with limits of performance of the various classes of lenses, and the different limits to be set in different directions according to the purpose for which the lens is required. A third section of the report deals with tolerances in confusion, stigmatic tolerances, and distortion allowable for different classes of lenses, such as process, kinematograph, or portrait lenses, oculars, condensers, etc. The many other directions in which specification is required are pointed out in the concluding paragraph. J. W. T. W.

66. *Photometric Units and Nomenclature.* **P. G. Nutting.** (Optical Soc. of America, J. 4. pp. 230–235, July, 1920.)—Describes a very complete system of radiation and photometric units, drawn up by the Society's Standards Committee on Photometry and Illumination. *Three systems* of units are *proposed*, namely: (1) a system of radiation units for dealing with radiant energy; (2) a rational system of photometric units for use in theoretical problems (*e.g.*, in pyrometry) involving both radiant energy and luminosity; and (3) a practical system of photometric units for dealing only with light in terms of light units and light standards. The first system is based on the Joule as the unit of quantity of radiant energy with the watt as the unit of flux. The units of the *rational system* are those corresponding in the radiation system multiplied by the visibility of radiation. Thus the unit of quantity of luminous energy is termed the light-watt-second, and the unit of luminous flux is the light watt. The units of the *practical system* are those of the rational system multiplied by the luminous equivalent of radiation in lumens per watt. Thus the unit of quantity of luminous energy in the practical system is the lumen-

second, while the unit of flux is the lumen. The unit of intensity or luminous angular density is the lumen per steradian or candle. New terms introduced are *opacity*, defined as the reciprocal of transmissivity (ratio of transmitted to incident light or energy); *density*, defined as the logarithm to base 10 of the opacity; and *scatter*, defined as Apparent density (specular light)/True density. A table is given for the relative visibility values of radiation from 400 to 760 $\mu\mu$ taking the visibility at 556 $\mu\mu$ as unity. The absolute values are also given, calculated on the assumption that the ratio of light to radiant energy at this wave-length is 660 lumens per watt. The following table gives the relation between sensitivity and brightness for the average eye:—

Average Brightness of Field Viewed (Millilamberts).	Relative Sensitivity of Retina.	Contrast Sensitivity Relative to Maximum.	Minimum Glaring Brightness of Field (Millilamberts).	Diameter of Pupil of Eye (mm.).
10^{-6}	0·77	0·017	20·1	7·4
10^{-5}	0·17	0·026	40·7	7·3
10^{-4}	0·038	0·043	89	7·2
10^{-3}	0·0077	0·078	186	7·0
10^{-2}	0·0018	0·22	400	6·7
0·1	0·00041	0·46	810	6·0
1	87×10^{-6}	0·83	1660	5·0
10	20×10^{-6}	0·98	3470	3·8
100	$3·7 \times 10^{-6}$	1·00	7250	2·7
1000	$0·33 \times 10^{-6}$	0·72	14,450	2·1
10,000	$(0·003) \times 10^{-6}$	0·36	30,900	2·0

In column 2 are given the values of general sensitivity of the eye in terms of that at the absolute threshold (about $0·70 \times 10^{-6}$ millilambert). The minimum glaring brightness is that just uncomfortably bright to an eye adapted to the brightness of the first column. J. W. T. W.

67 *Scattering of Light by Gases: Helium and Argon.* II. **Rayleigh.** (Roy. Soc., Proc. 98. pp. 57-64, Sept. 1, 1920.)—A continuation of previous work [Abs. 366, 1579 (1920)]. The present paper gives the results of work with helium and argon. A comparison was made of the total intensity of the scattered light with *helium* and air, and a mean value was obtained for the Helium/Air ratio of 0·0170. The theoretical value obtained by comparison of the squares of the refractivities is 0·0144, which shows fair agreement when account is taken of the fact that the helium was denser, which would lead to too high a value for that gas. In addition, it must be remembered that the theoretical relation is only approximate, depending as it does on the assumption of spherical symmetry in the scattering particles. The intensity ratio of the weak and strong components in helium was not definitely determined, as the weak component could not be detected; but the experiments carried out showed that the weak

image has certainly less than 6·5 % of the intensity of the strong one. The difficulty lies in the extreme faintness of the total scattering from helium, which makes the weak component (if there is one) too faint for detection. The early experiments with *argon* gave about the same value as for air, but subsequent experiments have led to quite a different result. It seems probable that in this case, as with the early experiments with helium, a fog must have been developed by some impurity in the gas. The results now obtained show that argon polarises much more perfectly than any of the common gases. A special method of determination for this gas gave for the ratio of the weak and strong components the value 0·0046, less than half of 1 %. A. W.

68. *Investigation of Turbid Media.* **T. Isnardi.** (Ann. d. Physik, 62. 7. pp. 573–588, Aug. 4, 1920.)—Experiments on the shape of colloidal particles were made first with gum-gutta. The resin is extracted from the material by alcohol, the solution evaporated to dryness, the glassy residue fused *in vacuo* and then poured on sheet celluloid to obtain plates of the resin; poured on glass the resin cracked. The resin plates gave for the range λ667·8 to 447·2, the refractive index 1·6125 to 1·6664. Absorption measurements were made with a König-Martens spectrophotometer, in order to determine the shape of the particles in the gum-gutta solution, whether discs, sphericles, or rods, after Gans; this method, though convenient for metallic colloids, failed. The absorption was, however, determined, and further the degree of depolarisation of the laterally scattered light; a Leybold trough is placed in front of the photometer and natural or polarised light is sent through the solution from either side. In these determinations it was found that the formula of Gans [Abs. 1232 (1920)] requires a correction for concentration.

Ultra-filters of Collargol.—The second part of the paper concerns collargol. It is pointed out that ultra-filters of freshly-prepared collodion and glacial acetic acid are transparent but not free of very small holes; the ultra-filters should not be used before they turn opalescent, which occurs in a week or two. The absorption measurements indicated ellipsoidal particles of axis-ratio 0·77, the depolarisation measurements indicated a ratio of 0·70. H. B.

69. *Colorimetrics.* **E. Schrödinger.** (Zeits. f. Physik, 1. 5. pp. 459–466, 1920.)—This is an abstract of a series of lectures, to be published in full later on. There is an enormous variety of lights of different spectral compositions and of physical excitations, but a much smaller variety of colours, of reactions to these excitations. The considerations are based upon Newton, Maxwell, Helmholtz, and Koenig, and the colour triangle is replaced by a pencil of vectors with 3 fundamental vectors. There are references to Kries and to Weber-Fechner, not to Edridge-Green. H. B.

70. *Contributions to the Theory of Colour.* **K. W. F. Kohlrausch.** I. (Phys. Zeits. 21. pp. 396–403, Aug. 1, 1920.)—Criticising the views as to the standpoint of the colour theory expressed by Ostwald in his summary of his work on pigment-colours [Abs. 926, 927 (1917)], the author adheres to Helmholtz and refers to F. Exner, "Characteristics of Beautiful and Ugly Colours." He distinguishes the remission function $\psi(\lambda)$, the energy distribution or illumination function $\phi(\lambda)$, and the light function

$f(\lambda) = \psi(\lambda) \cdot \phi(\lambda)$. When light is *remitted* by pigments, it is more weakened than by reflection from normal white, and this deviation from the normal ratio is indicated by $\psi(\lambda)$. To determine this function he makes use of the spectrophotometer of König as improved by Martens and Grünbaum. Such determinations are tabulated for the colour-circle of Ostwald. They enable him to classify pigments, not with respect to Ostwald's *b*, *g*, *r* (ratios of blue, green, red), but with respect to Helmholtz's F, S, H (tone, saturation, brightness).

II. *Brightness of Pigment Colours* (*ibid.*, pp. 423–426, Aug. 15, 1920). When $H = \beta b + \gamma g + \varsigma r$ can be determined for at least three colours, the β, γ, ς are known, and with the aid of Exner's principle of the additivity of heterochromous brightnesses, the F, S, H are numerically determinable. This holds only for one illumination (daylight, in this case), however, and only for a central normal vision, not affected by fatigue, etc.

III. *Remarks on Ostwald's Theory of Pigment Colours* (*ibid.*, pp. 473–477, Sept. 15, 1920.)—One of the difficulties of Ostwald's theory is that it is supposed to comprise the relationship of a colour to that of the surrounding medium; thus the medium must influence the colour, and the three coordinates can only then define a colour, when the medium is an ideal "full colour" of the same tone. On the whole, Ostwald's equation $f + w + s = 1$ (where w is the proportion of white, s of black, f of colour) may well serve for practical characterisation, but it does not constitute any theoretical advance. H. B.

71. *The Visibility of Radiation throughout the Spectrum.* **M. So.** (Phys. Math. Soc. Japan, Proc. 2. pp. 177–184, Sept., 1920.)—Curves showing luminosity throughout the spectrum have been obtained for twenty normal eyes, and for several colour-blind observers. These resemble closely the results obtained by observers in the United States and suggest that the distribution of luminosity for American and Japanese eyes is substantially the same. The author places the max. visibility at $0{\cdot}55\,\mu$, which is in exact agreement with the position ascertained by Nutting, and very near that adopted by Coblentz ($0{\cdot}558\,\mu$). The results are illustrated by tables and diagrams and a description of the apparatus used is presented. References to the work of previous observers are also given. J. S. D.

72. *Theory of Pigments of Maximum Light Intensity.* **E. Schrödinger.** (Ann. d. Physik, 62. 7. pp. 603–622, Aug. 4, 1920.)—That pigments are never saturated to the full degree of spectrum colours, but appear more whitish, is not only due to technical imperfections. When two spectrum colours (not too far apart) are mixed, the resultant colour is more whitish than the intermediate colour, unless the two colours lie both either in the red end or in the violet end of the spectrum, where the Newton-König spectrum-curve is straight, and not convex. The author examines the questions of the maximum attainable light intensity of pigments and of the requisite remission and absorption functions. He distinguishes long-end pigments (remission confined to red), short-end pigments (to violet), central pigments, and central-gap pigments (remissions both in red and violet). The conditions deduced hold for every illumination, *i.e.*, the pigment in question will not be surpassed in light intensity by any other pigment which emits light of the same tone with the same

illumination. Some of the—merely theoretical—deductions agree with Ostwald's observations. The author, however, does not accept the absolute values of Ostwald's determinations of purity and grey. H. B.

73. *Velocity of Light. Modification of Revolving Mirror Method.* **A. A. Michelson.** (Nat. Acad. Sci., Proc. 6. pp. 476–477, Aug., 1920.)—The two-faced plane mirror formerly used, which required a rotation of 180° while a beam of light passed from source to distant mirror, and back, is replaced by a solid prism. If on a square base 90° only is necessary and if on an octagonal base 45°. Details are given of the adjustments to reduce the errors of the angles of the prism to less than a tenth of a second of arc, and of the concentration of light by placing the revolving mirror in the focus of a long lens or mirror with light-source arranged to ensure max. intensity. With a speed of 1000 revs. per sec. a rotation of 45° can be made while the light passes twice between stations 12½ miles apart, or 90° for stations 25 miles apart, such as are projected for preliminary tests at Mt. Wilson. The octagonal mirror constructed for the purpose has faces 15 × 20 mm., which is sufficient to include the concentrated beam. W. W. B.

74. *Theory of Tone Reproduction, with a Graphic Method for the Solution of Problems.* **L. A. Jones.** (Frank. Inst., J. 190. pp. 39–90, July, 1920. Comm. No. 88 from the Eastman Kodak Co.'s Research Lab.)—The problem of ascertaining the exact extent to which it is possible by the photographic process to produce a pictorial representation of an object which will, when viewed, excite in the mind of the observer the same subjective impression as that produced by the image formed on the retina when the object itself is observed, has engaged the attention of workers in the field of photography for many years. There are many phases of the subject to be considered, and a complete treatment requires a careful analysis of the various factors upon which depend the operation of visual perception of space and spacial relations. A complete analysis, therefore, leads not only into the realm of physical science but also into those of psychology and philosophy. The proper production of brightness and brightness differences is of pre-eminent importance, and it is with this brightness factor and the possibility of its correct reproduction by the photographic process that this paper deals.

The problem may be divided into two general parts, the one, which may be termed the objective phase, dealing with the reproduction of the actual physical brightnesses and capable of being completely solved by purely physical methods; the other, the subjective phase, includes a consideration of those factors which determine the nature of the subjective impressions produced by the action of given physical stimuli under various conditions, and requires the use of psycho-physical methods and data for its adequate treatment. The following curves dealing with the objective side of the problem are given and explained: Characteristic curve of negative material; characteristic curve of positive material; contrast sensitivity curve of the eye; graphic solution for the objective phase of tone reproduction; curve of brightness deviations; curve of contrast deviations; characteristic of positive material required for exact reproduction; characteristic of negative material required for exact reproduction; determination of the negative contrast required for specified results; objective reproduction obtainable with specified materials and

conditions. For the subjective phase the following curves are given and explained: Relation between sensation and stimulus; special case of the complete solution including subjective phase; general case of the complete solution including the subjective phase. Attention is called to the fact that few data are at present available as to adaptation levels when the visual field is filled by areas of different brightnesses, such as exist under practical conditions. Experimental work is in progress, and when the data sought are available it will be possible by the application of the general principles here outlined to arrive at more certain conclusions relative to the exactness of reproduction in any particular case.

A. E. G.

75. *A Photographic Research Laboratory.* **G. E. K. Mees.** (Soc. Arts, J. 68. pp. 695–703; Disc., 703–705, Sept. 17, 1920.)—Diagrams are given showing the scope of the work which should be carried on in a photographic research laboratory, and some account of the researches completed in the laboratory of the Eastman Kodak Co. is given. Reference is made in a general way to the physics and chemistry of photography, to the reproduction of tone values, and to practical photography. A. E. G.

76. *Kerr-Effect; Dependence on Temperature.* **G. Szivessy.** (Zeits. f. Physik, 2. 1. pp. 30–48, 1920.)—This paper deals with the dependence of the eletro-optic Kerr-effect on temperature. A theoretical treatment is first given and then measurements are described on nitrobenzol. The temperature coefficient of the electro-optic constant B of nitrobenzol was measured for five different wave-lengths of the visible spectrum in the neighbourhood of the freezing-point. The formula $B = \text{const.} \times (\epsilon + 2)^2(n^2 + 2)^2 d/nT$ (where ϵ is the dielectric constant, n the index of refraction, d the density, and T the absolute temperature), which had up to the present only been verified for a single wave-length, was shown to hold good for all the wave-lengths used. The formula is deduced from the molecular orientation theory. Havelock's formula $B = h(n^2 - 1)^2/n\lambda$ (where h is Havelock's constant, λ the wave-length), which has previously been shown to hold good at about 20° C., was also found to be valid down to the freezing-point. Finally, the relation $hTd/(\epsilon + 2)^2 = \text{const.}$, deduced from the molecular orientation theory, and showing the dependence of h upon temperature, was well established. A. W.

77. *Investigation of the Ratio of the Absolute Retardations in Carbon Disulphide for Charges of Increasing Duration. Appearance of Electrostricture.* **Pauthenier.** (Comptes Rendus, 171. pp. 102–105, July 12, 1920.)—When the duration of charge of Kerr's condenser exceeds the millionth of a second, the ratio of the retardations in carbon disulphide no longer remains -2 [see next Abstract]. Experimental details are given for adjusting the time interval. Since the resistance of Kerr's condenser is of the order of 700 mégohms, it is possible to increase the duration of charge considerably without disturbance by the Joule effect. Two periods have been investigated: (1) Where the duration of charge is less than $\theta = 8{\cdot}1 \times 10^{-6}$ secs. Here the influence of electrostricture or contraction of the liquid under the influence of the electric field may be observed. The progressive increase in time by means of the experimental arrangement adopted has enabled the variation of the phenomenon to be investigated. A table of data together with a graph is given.

When $\theta = 8 \cdot 1 \times 10^{-6}$ sec., the electrostricture effect compensates the birefringence exactly for vibrations perpendicular to the field. (2) Where the duration of charge is greater than $\theta = 8 \cdot 1 \times 10^{-6}$ sec. The electrostricture is here found to increase to a maximum, then to decrease, again to increase very slowly, and finally to decrease to a static value which is positive.

[Erratum, *Ibid.*, p. 208, July 19, 1920.] H. H. Ho.

78. *Ratio of Absolute Retardations in Kerr's Phenomenon for Different Wave-lengths (Case of Nitrobenzene). Application of the Method of Instantaneous Charges to Carbon Disulphide.* **Pauthenier.** (Comptes Rendus, 170. pp. 1576–1578, June 28, 1920.)—In order to investigate the general character of the results already established for nitrobenzene [see Abs. 927 (1920) and preceding Abs.], experiments have been made to ascertain whether the absolute retardations depend on the wave length. Measurements are first recorded for yellow-green light using the Wratten B filter, then for red light using the Wratten A filter, and finally for blue light using as filter a convenient solution of copper sulphate. It is found that the ratio of the absolute retardations for nitrobenzene is equal to − 2, whatever may be the wave-length, provided the duration of charge be sufficiently short. When the duration is increased, the ratio slightly increases within the experimental limits investigated. These results are in complete accord with the theory of molecular orientation and with the hypothesis of a sign variation by electrostricture. Section II of the paper contains data for carbon disulphide. Since the latter is nearly 100 times less birefringent than nitrobenzene, the voltages used are in the neighbourhood of 30,000. For charges of short duration the ratio of the absolute retardations is also equal to − 2 for carbon disulphide.
H. H. Ho.

79. *New Effect of Radiation.* **F. Weigert.** (Zeits. f. Physik, 2. 1. pp. 1–12, 1920.)—A description of the effect dealt with has previously been given [Abs. 106 (1920)]. The present paper describes further investigations. Experiments were carried out with a photochloride gelatine emulsion, and it was shown that such a layer becomes anisotropic with lateral incidence of ordinary light, and the optic axis lies in a direction perpendicular to that of the incident light. The results for lateral incidence of ordinary light show the new effect to be analogous to the Tyndall phenomenon, to resonance radiation, and, to a certain extent, to the selective photoelectric effect. The results of quantitative measurements relative to the total absorption, dichroism, and double refraction exhibited by photochloride layers are presented graphically and also discussed. It appears probable that the effect is not concerned with the molecules of the substance themselves, but with molecular groups whose volume is small compared with the wave-length of light but large compared with molecular dimensions. A. W.

80. *Light Emitted by Metallic Vapours (Mg, Cu, and Mn) under Thermochemical and Thermo-electrical Excitation.* **G. A. Hemsalech.** (Phil. Mag 40. pp. 296–315, Sept., 1920.)—A continuation of previous work [Abs. 717 (1920)]. It was found that the vapours of any substance placed on the upper surface of the electrically-heated incandescent graphite plate pass automatically into the protected space beneath the plate. In this way

it has been possible to examine the spectra of a large number of substances, and to study the relative effects of thermo-chemical and thermo-electrical excitation upon their bands and lines. The method is described in detail and results are given for the spectra of Mg, Cu and Mn. The results show that the line-emissions due to thermo-electrical and to chemical excitation are both of the same type, the lines most strongly affected by the thermo-electronic current in the fringe being precisely those which are characteristic of the explosion region of the air–coal-gas flame [Abs. 1275 (1917)]. Their sensitiveness to electrical stimulation is further illustrated by the fact that their emission is appreciably enhanced in a capacity spark. The characteristic flame lines of Mg, Cu, and Mn, which in the air-coal gas flame are emitted by the mantle above the cone, appear all as long lines in the single-plate furnace. This fact confirms their status as temperature lines. A. W.

81. *Arc Spectrum of Cobalt.* **F. Dhein.** (Zeits. wiss. Phot. 19. pp. 289–335, June, 1920.)—This paper describes the measurements of the lines in the arc spectrum of cobalt in international units. The spectra were obtained by means of a large Rowland concave grating, and the plates used were specially sensitised when photographing the region of wave-lengths greater than λ5000. Tables are given of the wave-lengths of some hundreds of lines, from λ7417 to λ2590, and the results of Krebs and Stüting are included for comparison. A. W.

82. *Spectrum of Hydrogen Positive Rays.* **G. P. Thomson.** (Phil. Mag. 40. pp. 240–246, Aug., 1920.)—The evidence up to the present is rather conflicting as to the origin of the second or many-lined spectrum of hydrogen. Experiments were therefore undertaken to throw some light on the difficulties encountered. By changing the conditions in a discharge tube designed to produce positive rays it was found possible to vary the proportion of atoms to molecules in the positive rays over a wide range. The apparatus used is described in detail. Under certain conditions the molecular parabola could be made quite invisible at the higher pressures, and a photograph taken under these conditions showed only two lines (H_β and H_γ) of the Balmer series. H_α did not appear, as the plates were not sensitive to the red. From this it seems certain that the Balmer series is due to the hydrogen atom. It was never found possible to get a state of discharge in which the positive rays were exclusively molecular, but in certain experiments it is probable that there was a very large excess of molecules present. Photographs taken under these conditions leave no doubt that the secondary spectrum is caused by the hydrogen molecule. This result is confirmed by the results of other experiments, in which increasing proportions of molecules in the rays corresponded with increasing brightness of the second spectrum. When atoms only are present in the positive rays, the second spectrum occurs only very faintly, if at all. It is probable, however, that even in this case it is not entirely absent, and is due to the rays exciting the spectrum of the gas through which they pass (Stark's " Reststrahlen "). When molecules are present the second spectrum occurs in considerable intensity, and it would be expected to show the Doppler-effect if examined along the direction of motion of the rays. Stark and Wilsar [Abs. 600 (1913)] found that the second spectrum shows no such effect. The most probable explanation of this is that Stark and Wilsar never got molecules in their

positive rays at all. They used a narrow tube, which is not favourable to the development of molecules, and in Stark's work the p.d. used in the discharge tube never seems to have exceeded 7500 volts. In all the work done at Cambridge on positive rays fairly powerful induction coils have been used, and when a discharge is produced by these means in a tube at the low pressures found favourable for the production of molecular rays, the p.d. is much greater than 7000 volts. [See Abs. 561 (1916) and 637 (1917).] A. W.

83. *Spark Spectra of the Alkaline Earths and Arc Spectra of the Alkalies.* **E. Fues.** (Ann. d. Physik, 63. 1. pp. 1–27, Sept. 16, 1920.)—Kossel and Sommerfeld [Abs. 1201 (1919)] have given theory which shows definite relationships to exist between the spectra of different elements. In particular, relationships exist between the spark spectra of the alkaline earths and the arc spectra of the alkalies. The present paper examines in detail the latter question ; it shows how the various spectra are related, and points out the marked similarities which exist. A. W.

84. *Absorption Spectrum of Hydrogen Chloride.* **F. W. Loomis.** (Nature, 106. pp. 179–180, Oct. 7, 1920.)—The unexpected satellites which Imes [Abs. 222 (1920)] found beside each line in the HCl absorption band at $1{\cdot}76\mu$, and which measurements of his curves show to have an average wave-length 16 ± 4 Å. longer than the lines which they accompany, are readily accounted for as being due to the heavier of the two isotopes, atomic weights 35 and 37, of which Aston [Abs. 994 (1920)] has shown ordinary chlorine to consist. An approximate theory shows the wave-length of the band centre to vary as the square root of the effective mass $m = m_1m_2/(m_1 + m_2)$, where m_1 is the mass of the hydrogen nucleus and m_2 that of the chlorine atom. Taking $m = 35/36$ for the lighter, and 37/38 for the heavier isotope, the calculated difference between the wave-lengths of corresponding lines for the two isotopes comes out 13 Å. This is much larger than the differences of about 0·004 Å. which have been found between lines of the isotopes of lead by Aronberg [Abs. 678 (1918)] and Merton [Abs. 374 (1920)]. A more detailed account of the theory and measurements of these lines will be published later. A. W.

85. *Phosphorescent Sidot Blende.* **B. Gudden** and **R. Pohl.** (Zeits. f. Physik, 1. 4. pp. 365–375, 1920.)—The dielectric constant of this blende, which consists of crystalline zinc sulphide containing minimal traces of an admixed " active " metal [Abs. 810 (1910)], is found to be increased considerably under the influence of light. When monochromatic light is employed, this effect increases less rapidly than the intensity of the light. The latter not only initiates the effect, but is also able to destroy it. This phenomenon exhibits very pronounced spectral distribution, and appears to be connected with the crystalline structure of the blende ; it is not identical with the conductivity phenomena described as " actino-dielectric." T. H. P.

86. *Luminosity by Attrition.* **E. Heron-Allen** and **H. S. Allen.** (Nature, 106. p. 376, Nov. 18, 1920.)—Lankester has drawn attention to this phenomenon [*ibid.*, p. 310, Nov. 4, 1920]. It is now stated that pebbles showing the effect may be found on any shingle beach, and may be known by their translucent appearance under a " rotten " (or pitted)

exterior. They are *pale* brown, and when dry look like lumps of derelict toffee. On the shingle beaches of South Devon (notably the Budleigh Salterton Pebbles), the Chesil Beach, and the Suffolk coast, practically every pebble on the beach will "flash." The following points are noted: (1) Luminescence is produced when quartz is rubbed by any material, such as topaz or sapphire, which is harder than itself. Ordinary steel does not cause the glow. (2) Fused quartz gives a very fine effect. In this connection the observation of Rayleigh [Abs. 88 (1920)] that "silica glass" possesses a remarkable crystalline or quasi-crystalline structure, is of special interest. (3) Tubes of fused quartz when rubbed together give the same peculiar odour as ordinary quartz pebbles. It is suggested that the presence of minute diffused metallic particles, or perhaps particles of silicon itself, may be the cause of the various phenomena in question

A. W.

87. *Fluorimetry: New Method of Quantitative Analysis by Comparative Fluorescence. Preliminary Report.* **L. J. Desha.** (Am. Chem. Soc., J. 42. pp. 1350–1363, July, 1920.)—A new method of micro-analysis is described, of the same order of sensitiveness as colorimetry and nephelometry, which should prove generally applicable to the determination of minute quantities of the considerable number of substances which are either fluorescent themselves or are rendered so by addition of a suitable reagent. Ultra-violet rays from a quartz-enclosed mercury arc, filtered from most of the visible radiation, are used to excite fluorescence in solutions of such substances contained in the comparison cylinders of the Kober nephelometer. The intensity of the fluorescent light thus produced, as observed in the eye-piece of the instrument, is equalised in the usual manner by altering the heights of the exposed columns. For sufficiently dilute solutions the curves obtained by plotting the scale readings against concentrations are quite regular. These calibration curves are drawn for solutions containing 0·5–2 mgm. per litre of quinine sulphate in normal sulphuric acid and for solutions of 2–4 mgm. per litre of aniline iodeosin in decinormal alkali. Such a curve differs from that of inverse proportionality (the colorimetric curve) much more than from one drawn according to the nephelometric formula. Some peculiarities of the latter are indicated, and it is shown that when two constants are used (one for solutions stronger and the other for solutions more dilute than the standard) the values corresponding with the fluorometric readings may be taken from the nephelometric curve with an average error of less than 1 %.

T. H. P.

88. *Decay of Phosphorescence Excited by Positive Rays.* **G. Berndt.** (Zeits. f. Physik, 1. 1. pp. 42–44, 1920.)—Reference is made to the theory of Rutherford [Abs. 77 (1911)] relating to the decay of luminescence of a zinc-sulphide screen when bombarded by α-particles, and to the experimental work of Marsden [Abs. 76 (1911)] verifying Rutherford's theoretical deductions. Other physicists have examined similarly the phosphorescence produced by kathode rays.

The author now shows that Rutherford's deductions apply also to the case where phosphorescence is produced by positive rays. A. B. W.

89. *Symmetry of the Röntgen Patterns obtained by Means of Systems of Crystalline Lamellæ and Structure of Pseudo-symmetrical Crystals.* **F. M.**

Jaeger. (K. Akad. Amsterdam, Proc. 22. Nos. 9 and 10. pp. 815–830, 1920.)—According to Sohncke and to Mallard, the optical properties of uniaxial, circularly-polarising crystals may be accounted for by the supposition that such crystals are only apparently more highly symmetrical intergrowths of numerous extremely thin and often submicroscopic crystalline lamellæ of lower crystallographic symmetry. In order to obtain a more exact insight into the real behaviour of such pseudo-symmetrical crystals with respect to the phenomenon of the diffraction of transmitted Röntgen rays, the author has studied the specific symmetry of the Röntgen patterns furnished by systems of superposed mica lamellæ. The results obtained point to a close analogy with the anomalies formerly found with real pseudo-symmetrical crystals, but at the same time indicate that, in so far as tetragonal crystals endowed with circular polarisation are concerned, the views of Sohncke and Mallard cannot be considered to give a final explanation of the phenomena observed. T. H. P.

90. *Continuous X-ray Spectrum of the Hot-kathode Tube ; Dependence of the Grenzstrahlung on the Azimuth of Emission ; and the Influence of the Antikathode Metal.* **G. Zecher.** (Ann. d. Physik, 63. 1. pp. 28–56, Sept. 16, 1920. Dissertation, Frankfort.)—A description of experiments with hot-kathode X-ray tubes with molybdenum and tungsten antikathodes, over a range of voltages up to 80,000 volts. Careful measurements have been made of the wave-length limits of the continuous spectrum.

Using two X-ray spectrographs, the relation between the short wave-length limit and azimuth of emission has been studied. The displacement of the limiting wave-length with azimuth of emission has been found to be a pure Doppler-effect. The ratio of this wave-length for angles 60° and 210°, $\lambda_{60}/\lambda_{210} = 0{\cdot}89 \pm 0{\cdot}02$, is in good agreement with theory (taking the ideal case of rectilinear and uniform "Bremsung") which gives 0·69.

To examine how the limiting frequency is dependent on the metal of the antikathode, a comparison has been made of two similar hot-kathode tubes with tungsten and molybdenum targets. For the same h.t. voltage the molybdenum tube gave a harder radiation than the tungsten tube. The observations were not sufficient to decide definitely on the influence of antikathode material. A. B. W.

91. *K Series of X-rays.* **W. Duane** and **W. Stenström.** (Nat. Acad. Sci., Proc. 6. pp. 477–486, Aug., 1920.)—Measurements are given of the *wave-lengths* of the emission lines of the K series of tungsten, an examination of *critical absorption* in this series being also described. In order to obtain precise values of the wave-lengths, spectra of the first, second, third, fourth, and fifth orders have been employed. The object of the investigation was to provide data for testing the following points : (*a*) The existence of a third line in the α-group ; (*b*) the separation of the critical absorption from the line of shortest wave-length in the emission spectrum (namely the γ-line) ; (*c*) the experimental and theoretical relations between the various lines in the K, L, M, etc., series ; (*d*) the relative intensities of the emission lines ; and (*e*) the equations for the wave-lengths that may be deduced from theories of atomic structure and the mechanism of radiation. A. B. W.

HEAT.

92. *A Graphical Representation of the Equation of State.* **R. Mollier.** (Phys. Zeits. 21. pp. 457–463, Sept. 1, 1920.)—If the van der Waals equation $p = RT/(v - b) - a/v^2$ be put in the form $pv^2/T = Rv^2/(v - b) - a/T$, and the magnitudes pv^2/T be plotted as ordinates against any volume or temperature function as abscissæ, then two diagrams are obtained in which the isotherms or isochors respectively become congruent displaced curves in the direction of the ordinates. The same result holds good for numerous other equations of state which may be expressed in the form $p = \phi(v)T + \psi(T)/v^2$. The paper consists entirely of examples, when pv^2/T is plotted against the density and $1/T$, namely :— for hydrogen, helium, nitrogen, air, oxygen, carbon monoxide, carbon dioxide, ethylene, isopentane, and ether. Numerous curves illustrate the various discussions. H. H. Ho.

93. *Indirect Method of Determining the Specific Heat of Dilute Solutions, with Preliminary Data concerning Hydrochloric Acid.* **T. W. Richards** and **A. W. Rowe.** (Am. Chem. Soc., J. 42. pp. 1621–1635, Aug., 1920.)—The specific heat of a dilute solution may be determined indirectly from the difference between the amounts of heat evolved on diluting a solution, of known concentration, to the desired strength at two different temperatures. The method is based on the familiar consequence of the first law of thermodynamics known as Kirchhoff's law, namely : $K_M - K'_M = (U' - U)/\Delta\theta$, where K_M and K'_M represent respectively the molar heat capacities of the reacting substances and of the products, and U and U′ the respective total energy changes—in the case in hand the heats of dilution at the temperatures θ and $\theta + \Delta\theta$. Thus, when once the heat capacity of a concentrated solution has been measured, that of any less concentrated solution may be obtained merely by measuring two heats of dilution, this being easier than measuring directly one specific heat.

The calorimetric apparatus employed is described in detail and the data for various dilutions of hydrochloric acid are given. T. H. P.

94. *Specific Heat of Saturated Vapours at Low Temperatures. Reply to a Note by G. Bruhat.* **E. Ariès.** (Comptes Rendus, 171. pp. 456–458, Aug. 30, and pp. 986–989, Nov. 22, 1920.)—Bruhat has recently attempted to establish that the specific heat of a saturated vapour, which is very great and negative at low temperatures, tends towards $-\infty$, at absolute zero [see Abs. 1179 (1920)]. This result, while in conformity with that obtained by other workers, differs considerably from one arrived at by the present author, whereby the coefficient m' is found to be very small and positive in the neighbourhood of absolute zero and to vanish at this temperature. The author confines his demonstration to the formulæ employed by Bruhat. He points out, by taking the volume and pressure as coordinates and plotting the saturation curves, that the coefficient m' cannot be negative at low temperatures. This coefficient is equal to $T \cdot \partial s/\partial T$ by definition, s being a function of the temperature which represents the value of the entropy upon the saturation curve. Now, in the vicinity of absolute zero, s increases with the temperature and $\partial s/\partial T$ is essentially positive. The refraction of the adiabatic lines also tends to

disappear as the temperature approaches absolute zero, as may be derived from Bruhat's formulæ. An alternative argument is also given, based on Bruhat's formulæ. Reciprocally, assuming that $m' = 0$, Bruhat's formula is deduced for the vapour tension. Two other conclusions are drawn by simple inspection, namely: (1) The heat of vaporisation of a liquid tends towards zero to the extent that the temperature approaches absolute zero, and not towards a finite value L_0 as assumed by Planck. (2) The entropy of the saturated vapour emitted by this liquid, which is the minimum entropy of the body reduced to the state of a perfect gas, tends towards the same value as the specific heat at constant pressure of the perfect gas when the temperature approaches absolute zero. **G. Bruhat.** (*Ibid.*, p. 712, Oct. 18, 1920.) H. H. Ho.

95. *Thermo-Elements of Non-precious Metals for High Temperature Measurement.* **F. Hoffmann** and **A. Schulze.** (Elekt. Zeits. 41. pp. 427-433, June 3, 1920. From the Physikal.-Techn. Reichsanstalt.)—Describes experiments on the use of alloys of nickel, constantan, chromium, and steel instead of Pt and Pt-Rh for pyrometric measurements from 600° to 1200° C. J. W. T. W.

96. *Calorimetric Method for Standardising Thermometers by Electrical Energy.* **T. W. Richards** and **S. Tamaru.** (Am. Chem. Soc., J. 42. pp. 1374–1377, July, 1920.)—This method consists in supplying successive small quantities of heat as electrical energy to a definite quantity of water in a calorimeter, the corresponding readings of the calorimeter being observed. Comparison of the actual rise of temperature in each case with that calculated from the known heat capacity of the system indicates the error of the thermometer. T. H. P.

97. *Radiometer Measurements; Effect of Gas Pressure and Nature of the Gas.* **W. H. Westphal.** (Zeits. f. Physik 1. 1. pp. 92–100, and 1. 5. pp. 431–438, 1920.)—This paper presents the results obtained in an investigation of radiometer effects over a wide range of pressures, and includes the dependence of radiometer action on the gas pressure and on the kind of gas used. The symmetry of the curve connecting the radiometer action with the logarithm of the gas pressure was observed in earlier work [Abs. 1066 and 1188 (1919)], and this symmetry has been confirmed for a wide pressure range. A slight deviation from symmetry occurs first at a pressure of about 0·001 mm. of mercury. If the radiometer effect at pressure p be denoted by R, R_0 being the max. effect at pressure p_0, then $R/R_0 = f(\log p/p_0)$ is called the radiometer function. The behaviour of the radiometer function is, for thinly blackened radiometers which at higher pressures show a negative effect, naturally not symmetrical. It is, however, symmetrical if the relative radiometer effect R/R_0 is considered as a function of $\log (p + \pi)/(p_0 + \pi)$, where π is a constant of different magnitude for each thickness of the black coating. The radiometer function for the same radiometer is practically the same for different gases, and does not differ very appreciably for different radiometers. The wave-length of the radiation falling on the radiometer is, within the visible region of the spectrum, without effect on the radiometer function. The max. radiometer effect for water-vapour occurs at a lower pressure than for air. In agreement with previous observation, the explanation of this is to be found in the fact that the max. radiometer effect is found at a

pressure which is the lower the greater the number of atoms in the gas molecule. A. W.

98. *Calculation of the Heat of Sublimation of Alkali Halides from their Lattice Structures.* **A. Reis.** (Zeits. f. Physik, 1. 4. pp. 294–298, 1920.)—In calculating the energy of the ionisation of alkali halides Born [Abs. 686 (1919)] had made use of the "lattice potential" a of Madelung. The author introduces in its place the constant a' which refers to the molecule, not to the elementary cube, and extends the consideration from the crystal lattices to the molecules of the salts. The thus calculated heats of sublimation represent about 32 per cent. of the ionisation heats for the alkali halides (compounds of K, Na, Rb, Cu with Cl, Br, I), except in the case of Li, where the calculated values are much smaller. These heats of sublimation have not yet been measured; the calculated values agree fairly with Haber's estimates, however, except again in the case of Li. H. B.

99. *Ignition of Gases at Reduced Pressures by Impulsive Electric Sparks.* **W. M. Thornton.** (Phil. Mag. 40. pp. 345–356, Sept., 1920.)—Having observed step ignition in gases at pressure above atmospheric [Abs. 82 (1915)], the author finds similar steps in gases (hydrogen, methane, ethane, propane, carbon monoxide, coal gas) at reduced pressures, down to about 0·25 atmo. A large induction coil is used, the primary condenser short-circuited, and the circuit broken by a rapid switch. Whilst ignition by hot wires could easily be obtained at 0·13 atmo., none of the gases could be ignited by the impulsive sparks below 0·25 atmo. The spark is said to pass between the platinum electrodes when there is a complete bridge of ions; but that discharge may or may not cause ignition, the intensity of the spark, the number of ions produced per unit time, and the temperature of the sparking point being also of influence. Steps are observed in hydrogen and methane, not in ethane and propane; oscillations are, however, noticed in these latter gases. There is a close agreement between the steps (the pressures at which sudden changes in inflammability occur) and the partial pressures corresponding to the points at which oxygen has ratios to the mass of combustible gas expressed by successive natural numbers. Coal gas (with 50 % H) behaves like hydrogen, but does not show the peculiar oscillation of hydrogen near 0·4 atmo. H. B.

100. *The Self-Ignition of Ether–Air Mixtures.* **J. A. McClelland** and **H. V. Gill.** (Roy. Dublin Soc., Proc. 16. pp. 109–119, Aug., 1920.)—Investigating the "shock-ignition" of White and Price [see Abs. 1445 (1920)], the authors pass the mixture of ether vapour and air from a reservoir R through a tap (worked by a spring) and a connecting tube CT (1 in. diam., 30 in. long) into a wider explosion tube ET (3 in. diam., 3 ft. or more long), generally closed at the far end D by a glass plate, near which the flame appeared, sometimes travelling back and causing explosion. R was mostly at atmospheric pressure; in CT and ET a vacuum was maintained, and thermo-couples were placed in ET. This latter tube should be above 1 in. diam. and at least 3 ft. long (though probably not longer than 6 ft.) to cause explosion; the gas pressure in ET should be about 3 or 4 cm. Hg, not above 5 cm.; the pressure in R did not matter. Plugging the tube near D with cotton wool or with several

(6) layers of wire gauze prevented ignition. The temperature in ET rose towards D to a maximum of 193° C. [compare Alilaire, Abs. 1444 (1920)]; this gradual rise of temperature may be ascribed to the rush of ether vapour meeting the reflected gas stream. No ignition was observed when ET was replaced by a bell jar. H. B.

101. *Ignition of Gases.* I. *Ignition of Methane–Air Mixtures by the Impulsive Electrical Discharge.* **R. V. Wheeler.** (Chem. Soc., J., Trans. 117. pp. 903–917, July, 1920.)—In the experiments discussed ignition is effected by the high-tension spark passing across a gap in the secondary circuit of an induction coil when the primary is broken. With Morgan, the author assumes that the discharge consists of two successive phases, a capacity component (electrostatic energy) of very short duration and an inductance component (electromagnetic energy) of longer duration, but of minor importance for the ignition. The gap was always horizontal in a glass globe of 75 cm.^{3} between stout Pt wires, 2 mm. in diameter, coated with glass to within 1 mm. of their ends. Ignition was under equal conditions mostly re-obtained by a few sparks. Sometimes, however, it required 50 discharges, and in such cases it was always found that the polished steel points of the primary circuit breaker were partly oxidised or that a dust speck had settled on one of them. There was indication of "stepped ignition" which, contrary to Thornton and to Paterson and Campbell, the author ascribes to want of constancy in the experimental conditions, especially also at the electrodes. The mixtures ignited need not necessarily be capable of propagating the flame; ignitibility (as distinct from inflammability) corresponds rather to the appearance of a cap, which may become several inches long in a miner's lamp, although the lower limit of inflammability, 5·5 % of CH_4, has not yet been reached. In some of the determinations of the igniting current the primary gap was kept constant whilst the secondary gap was varied. For reasons stated the ignitibility curves do not indicate the limits of inflammability; the ignitibility hardly depends upon the thermal conductivity and the specific heat of the mixture, and the curve of speed of flame propagation is nearly the inverse of the ignition current curve. The intensity of the secondary discharge necessary to cause the ignition of a certain mixture seems mainly to be dependent upon the initial speed with which a flame can travel in the mixture. Discharges by currents slightly less than the igniting currents were accompanied by minute tongues of flame of inverted V shape, shooting out above and below the spark-gap. H. B.

102. *Propagation of Flame in Methane-Air Mixtures.* II. *Vertical Propagation.* III. *Propagation in Currents of Mixtures.* **W. Mason** and **R. V. Wheeler.** (Chem. Soc., J., Trans. 117. pp. 1227–1240, Oct., 1920.)—According to le Chatelier the "uniform movement" would be the "normal flame propagation" due to the conduction of heat from layer to layer, observable in tubes wide enough to prevent cooling by the walls, but sufficiently narrow to prevent the influence of convection currents. This view is found to be untenable. The uniform movement is simply a particular phase in flame propagation and does not arise from any particular mode of heat transference. There is always uniform movement in vertical tubes ignited at the open end and closed at the other. The downward propagation in tubes 5 in. long, 5 cm. diameter,

is of the same curve type as the uniform movement in horizontal tubes, but the speed is only $\frac{2}{3}$ of the latter [Abs. 586 (1920)]. With upward propagation the speeds are irregular, but not greater than for the uniform movement. With mixtures containing from 9 to 11 per cent. of methane resonance effects of the tube come in, and photographs of the flames in quartz tubes show that the flame front is symmetrical as long as there is no resonance, but asymmetrical when resonance sets in. When a tube is open at both ends, the tube becomes a chimney, and the turbulence set up increases the speed of propagation. In this case the maximum speed is observed, not with methane percentages of about 10 (as ordinarily), but with 12 % of methane. Vertical tubes ignited at the closed end, open at the other, behave like horizontal tubes. The effects of sending currents of the gas mixtures through tubes at different speeds are studied in horizontal brass pipes open at both ends, the velocity of the gas stream ranging up to 75 cm./sec. Turbulence is set up and the lower limit of inflammability of the gas-mixture is lowered, as experiments with percentages of CH_4 of 5·15, 5·10, 5·05, 5·02, 5·00, etc., show. In the 5·00 % CH_4 flame would not travel more than 50 cm., even at high gas velocity, and the poorer mixtures of 4·95, 4·90, 4·85 % simply gave short flares of flame. Though the experiments have not yet been sufficiently varied, it would appear that a flame would not, in the roadway of a mine, travel in 5·0 % CH_4, but it would travel along the roof in 5·2 % CH_4, with a current of from 35 to 65 cm./sec. H. B.

103. *Pressure and Temperature Relations for Vapour of Liquids.* **P. B. Williamson.** (Chem. and Met. Eng. 22. pp. 1151–1155, June 23, 1920.)—The author, while working out the design of a cracking process for producing gasoline, required some qualitative idea of the change, under different pressures, of the boiling-points of quite a large number of hydrocarbons, especially paraffins. Very little published matter exists on the vapour-tension phenomena of these compounds, and substantially nothing has been done towards determining a general relation between the temperature of a liquid and its corresponding vapour tension. The present paper, therefore, discusses the derivation of formulæ giving the relations of vapour pressures, namely: Boiling pressure ratios to the absolute temperature; absolute boiling-point ratios from known physical constants; latent heat of evaporation, molecular weight, and absolute boiling-point. The investigation gives a basis for the statement that the temperature of a liquid varies with changing vapour tension according to the logarithmic law; the natural logarithm of any particular temperature (absolute) being equal to a known function of the vapour pressure, plus the natural logarithm of the normal boiling-point. The expression deduced is:

$$p = [1 + 0{\cdot}1325 W L_b (\log T_p - \log T_b)/T_b]^9$$

or

$$L_b = 0{\cdot}1325 W (\log T_p - \log T_b)(p^{1/9} - 1)^{-1}/T_b,$$

where p is the pressure in atmospheres, W the molecular weight of the liquid, L_b the latent heat of vaporisation at the normal boiling-point of the liquid, T_p the temperature of the liquid, and T_b the normal boiling-point (abs.) of the liquid. On application of the formula the results were much better than anticipated, only three really glaring departures occurring—those of formic and acetic acids and acetic anhydride. The expression, therefore, appears to hold for liquids in general, and naturally suggests similar ones for other property variations. H. H. Ho.

104. *Calculations with the Williamson Formula.* **W. Savage.** (Chem. and Met. Eng. 22. pp. 1155–1156, June 23, 1920.)—Some months ago Williamson contributed his modification of Bertrand's empirical vapour-pressure formula in editorial correspondence in the above journal. Publication of it was withheld for a time because it did not appear to offer Williamson sufficient assistance towards computation celerity. However, a new formula has been subsequently developed [see preceding Abs.] which can readily be worked with by means of a $\log_e - \log_{10}$ slide rule or an alignment chart having similar scales together with a special ninth-root scale. Such a chart has been designed by the present author, and is included herewith together with a detailed exposition of procedure and problem solutions, as, for example, to find to what temperature mercury would have to be heated to give a pressure of 10 atmos. A very comprehensive data table is included. H. H. Ho.

105. *Correspondence of Substances in the Solid State.* **F. Michaud.** (Comptes Rendus, 171. pp. 241–243, July 26, 1920.)—The characteristic surfaces for different bodies, constructed by taking the critical constants for specific units, are superposable ; this constitutes the law of corresponding states, although the surfaces, which fit exactly in the region of the critical point, begin to differ with the distance from the latter and in the region of the solid state are widely divergent. The law of corresponding states has been generalised by making any homologous points coincide instead of the critical points, and taking the coordinates of these points as specific units. By this means a perfect superposition of surfaces can be obtained, in principle, for any region arbitrarily chosen. In practice, the difficulty arises of finding homologous points capable of being fixed with precision. This difficulty is not insurmountable, since D. Berthelot has shown that in the gaseous region three points may replace the critical point as centres of correspondence. The object of the present paper is to show that another exists in the solid region, *e.g.*, where the divergence from the ordinary law of corresponding states makes such a point particularly useful. For all bodies hitherto investigated, the specific heat C tends towards zero when the temperature T approaches absolute zero, as also $dc/d\mathrm{T}$. The quotient C/T should therefore vanish for $\mathrm{T} = 0$, and, since it tends towards zero for $\mathrm{T} = \infty$, it necessarily passes through a max. value. The latter point is used as a centre of correspondence, and is shown to play an analogous *rôle* for the solid state to that of the critical point for the fluid state. Data and curves are given for the five bodies whose specific heats at low temperatures are known with certainty, namely : aluminium, silver, copper, lead, and zinc. Each curve shows the predicted maximum which is fortunately very well defined. It is thus seen that the law of Dulong and Petit is only accurate at high temperatures because of the constancy of the specific heats. The atomic entropies at temperatures proportional to these maximum-point temperatures are therefore equal. H. H. Ho.

106. *Derivation of a Formula for the Temperature Dependence of the Velocity Constants in Gas Reactions from a Special Image of the Process.* **J. Tresling.** (K. Akad. Amsterdam, Proc. 23. 1. pp. 143–148, 1920.)—Using a definite image of the dissociation, Boltzmann derived a formula for the equilibrium constant in gas reactions. Using a similar image, the present author deduces formulæ for the temperature dependence

of the velocity constants in gas reactions. For the dissociation constant K, the formula $K = \frac{1}{2}we^{-\psi/\kappa\tau}$ is obtained, w being the volume of the sphere of attraction. For the velocity constants k_1 and k_2 of a dissociation, $k_1 = S/w \cdot e^{\psi/\kappa\tau}\sqrt{(k\tau/\pi m)}$, and $k_2 = \frac{1}{2}S\sqrt{(k\tau/\pi m)}$, where S is the surface of the layer.

The paper is entirely mathematical. H. H. Ho.

107. *Determination of the Last of the Three Functions which Define the Equation of State for Ether.* **E. Ariès.** (Comptes Rendus, 171. pp. 154–156, July 19, 1920.)—The functions x and Φ, that is, two out of the three temperature functions defining the equation of state for ether, were determined in a previous communication [see Abs. 406 (1920)]. There now remains the function "a" which enters into the formulæ:—

$$v_1 = RT_c/8P_c \cdot x/\Phi \cdot (a + y_1)$$
$$v_2 = RT_c/8P_c \cdot x/\Phi \cdot (a + y_2)$$

and which, at each temperature, is necessary for calculating the molecular volumes of ether in its two states of saturation. x and ϕ being already determined, the author submits for "a" the expression $a = a_c + (1 - \tau)^2/10\theta$, where θ is a polynamical of the third degree in τ:—$\theta = (1/0{\cdot}0073688)(A + B\tau + C\tau^2 + D\tau^3)$. It is then deduced that $a_c = 0{\cdot}09809$, following which the constants A, B, C, and D are calculated. The molecular volumes v_1 and v_2 are then determined for ether for a temperature range 0° to 190° C. A comparison table is given for Young's data and those calculated as above. The functions x, Φ, and a define completely the three functions ϕ, α, and β which enter the equation of state $p = RT/(v - \alpha) - \phi/(v + \beta)^2$, and show the necessity for the Clausius modification of van der Waals' equation, whereby the covolume "β" is introduced in the denominator of the second term, this varying with the temperature like the covolume "α" and for ether, at the critical temperature, attaining a value 9 times greater than the covolume "a" of van der Waals. H. H. Ho.

108. *Form and Area Factors for Evaporation.* **W. Gallenkamp.** (Meterolog. Zeits. 36. pp. 16–22, Jan.–Feb., 1919. Monthly Weather Rev. 47. p. 857 with Disc., Dec., 1919. Abstract.)—Circular atmometer surfaces from 2 to 8 cm. in diameter were rotated on a wooden framework in calm air. The wind to which each was exposed could thus be regulated by adjusting its distance from the axis, while conditions as to humidity and temperature were the same for all. The depth of water evaporated is found to decrease, with increasing diameter of the surface, rapidly at first and then more slowly, following a kind of parabolic law. The percentage decrease for identical conditions as to wind, etc., is independent of the wind speed. The experiments being extended to square and rectangular surfaces, it is found that the depth of water evaporated depends not only on the size of the surface but on its form and position with respect to the wind direction. An empirical relation is obtained, namely, $V_1/V_2 = B_1L_1^{0{\cdot}6}/B_2L_2^{0{\cdot}6}$, where V_1 and V_2 are the volumes of watere vaporated per unit time from surfaces of mean length L_1, L_2 in the direction of the wind and total breadth B_1, B_2 perpendicular to it. For circular atmometers, diameters d_1, d_2, this relation is $V_1/V_2 = d_1^{1{\cdot}6}/d_2^{1{\cdot}6}$, agreeing well with Jeffrey's theoretical result [Abs. 691 (1918)] in which the power of the diameter is 1·5. An investigation of the

effect of salt in solution and of impurities on the surface of stagnant water shows that in each case the effect is to reduce the rate of evaporation by a percentage varying considerably according to the strength of the solution or nature of the impurity.

New Type of Atmometer.—The author describes an atmometer which is the inverse of the rain gauge. The evaporation takes place from a circular filter-paper of area equal to that enclosed by the rim of the standard rain gauge. A wick passing from the under side of the filter-paper into a vessel containing distilled water keeps the paper moist. The loss by evaporation is found by measuring the water, before and after, with the rain gauge measuring-glass. M. A. G.

109. *Critical Study of Ethyl Ether.* **Andant.** (Comptes Rendus, 170. pp. 1573–1575, June 28, 1920.)—The critical temperature for ether is found to satisfy the following relation: $T_c = 190{\cdot}22° + 11D - 10D^2$, where D is the density of the tube charge. A study of the critical opalescence has been made by F. B. Young's direct comparison method. The opalescence of the ether tube is compared with that of opalescent solutions. Among the latter utilised (milk, absinthe, soap, and alcohol, essence of lemon, and precipitated sulphur), milk and essence of lemon afford exact correspondences with the opalescence of ether at its critical temperature. On heating, the opalescence commences at 0·5 deg. below T_c and finishes at 2·5° C. above, while on cooling, opalescence commences at 2·5 deg. above T_c and finishes at 0·55 deg. below. These results confirm Smoluchowsky's hypothesis, that the opalescence diminishes more slowly when the temperature rises above the point of separation than when it falls below it. F. B. Young has given 0·5 to 0·6 deg. C. as the lower, and 3 deg. as the upper limit respectively. The author has constructed curves showing the intensity of opalescence as a function of the temperature. The temperature of max. opalescence is a function of the tube charge, and the difference between T_c and the above temperature increases with the density of the charge, as also does the intensity of the opalescence. With falling temperatures the opalescence appears more intense than with rising temperatures. A spectrophotometric study is promised. H. H. Ho.

110. *Thermodynamics of the Uncommon States in Vapour Spaces (Thermal Ionisation and Thermal Luminosity).* I. **W. Schottky.** (Ann. d. Physik, 62. 2. pp. 113–155, May 28, 1920. Habilitationschrift, Würzburg.)—The ordinary properties of thermodynamical systems (specific heat, space-filling, capacity for doing work) depend upon average conditions. In the striking electric and optical phenomena (conductivity, ionisation, radiation) attention is paid rather to special features than to statistics. The author endeavours to give a general thermodynamics, including the rarer phenomena of the latter class. In examining the definitions of certain electrochemical and thermodynamical conceptions, he starts from the view of Stern, Herzfeld and Laue that the value of the gas constant is applicable to the electron gas, and from his own equation $l^- + l^+ = l^x + j$, where the l are the molecular heats of vaporisation for electrons, positive ions, and neutral atoms, and he considers first the question, how the absolute value of the density of a vapour is connected with the absolute value of the potential. The vapour pressure of electrons and ions might not appear to be thermodynamically

definite in the same sense as the vapour pressure of neutral atoms. The considerations are difficult, since the laws of thermodynamical equilibrium are either given in the form of differential equations or involve equations of state. The difficulty is overcome in the "μ thermodynamics" of Laue's vapour-pressure formula, where μ is the free energy of a particle (charged or uncharged) with respect to the solid phase. The author discusses in Part I the free energy of the solid phase, the work of ionisation, the galvanic and the voltaic potential, and the free energy of the vapour phase. The galvanic p.d. at the contact surface of two metals is given by the difference of the natural free energies of the electrons in the two metals. The voltaic p.d. between two boundary surfaces outside two conductors is given by the total free energy of the electrons in the two conductors with respect to the two boundaries selected. H. B.

111. *Equation of State for Ether.* **E. Ariès.** (Comptes Rendus, 170. pp. 871–875, April 12, 1920.)—The author first refers to his equation of state which in theory represents the thermal properties of fluids, but which presents certain difficulties in practice for the case of ether. Of the five formulæ which can be derived concerning the state of saturation, those giving the vapour tension, the heat of vaporisation, and the difference of the molecular volumes taken in the two states of saturation, only introduce the function ϕ and the sum $\alpha + \beta$ of the covolumes. The remaining two formulæ give the volumes v_1 and v_2 separately in addition to the function α. The problem investigated in the present paper is the determination for ether of ϕ and $v = \alpha + \beta$. Simplicity of calculation has been the author's aim, as also the introduction of not more than three numerical constants. The two functions concerned are replaced by two others which are equivalent, and whose temperature variations are more regular. The formulæ then deduced are found to furnish results in close agreement with experimental data, *e.g.*, 85·63 cals. for the heat of vaporisation of 1 gm. of ether, a value which only differs by 1/200 from the 85·18 cals. given by Young. H. H. Ho.

112. *The Thermodynamic Properties of Fluids in the Neighbourhood of the Critical State.* **C. Raveau.** (Comptes Rendus, 171. pp. 471–473, Aug. 30, 1920.)—Relationships concerning adiabatics and isothermals in the neighbourhood of the critical point which were recently published [Abs. 768 (1919)] are now deduced simultaneously by a different method which considers the variation of available energy accompanying changes in dv and dT at the critical point. The paper is mathematical throughout. H. H. Ho.

113. *Extension of Boltzmann's Kinetic Theory of Gases to the Case of External Forces Dependent on the Molecular Velocities.* **G. Polvani.** (N. Cimento, 19. pp. 173–192, April, 1920.)—Mathematical.

114. *Certain Results of a Study of the Vapour-Pressure Problem.* **L. Schames.** (Zeits. f. Physik, 1. 3. pp. 198–203, 1920.)—It is shown that from the integral vapour-pressure function, $f_1 = lnp/(1 - 1/t)$ [see Abs. 1019 (1914)], important results may be derived concerning the latent heat and the chemical constants of substances. T. H. P.

SOUND.

115. *The Tones from Bells.* **A. T. Jones.** (Phys. Rev. 16. pp. 247–259, Oct., 1920.)—*Normal Modes of Vibration.*—The positions of the *nodal lines* are examined for partial tones up to the ninth. Certain partials are heard only when the bell is tapped on the sound bow, others only when it is tapped above the sound bow.

Elasticity.—A value is obtained for the *Young's modulus* of bell metal.

Striking Notes.—The *principal striking note* is the note which is best heard when tunes are played on bells, and which gives its name to a bell. It cannot be picked up from the bell by a resonator, it cannot be elicited from the bell by resonance, and it does not beat with a tuning-fork of nearly its own pitch. No partial tone of the bell has the same pitch as this striking note, but the fifth partial is an octave above it. A striking note is not a difference tone, and it does not arise from compressional waves running through the material of the bell. The pitch of the striking note seems to be determined by the fifth partial, the octave in which it lies being, however, generally misjudged. A possible reason for this general failure in correct estimation of the octave is found in the rates at which the different partials reach their maximum intensities.

A *secondary striking note*, an octave below the fourth partial of the bell, can be heard when the bell is tapped above the sound bow. [See also Abs. 128 (1920).] AUTHOR.

116. *The Performance of Conical Horns.* **G. W. Stewart.** (Phys. Rev. 16. pp. 313–326, Oct., 1920.)—The experiments were performed to secure quantitative results with a conical horn used as a receiver. The approximate theory of A. G. Webster, when extended, and the experimental data herein presented lead to the following conclusions concerning such a horn acting as a receiver:—

Intensity at Vertex as a Function of Frequency.—The experimental variations of intensity at the vertex plotted with changing frequency, intensity of the arriving waves constant, demonstrate that: (*a*) The frequencies producing resonance are very closely integral multiples of the fundamental frequency. (*b*) The resonance peaks broaden and the minima between the peaks increase with increasing frequency. (*c*) Therefore the conical horn used as a receiver gives an amplification for any frequency nearly the same or greater than the fundamental. (*d*) The greater the frequency, the less the differences between maxima and minima, and thus a horn long compared to the wave-length of the least frequency involved gives an amplification without highly marked resonance characteristics. (*e*) The function of frequency obtained experimentally varies with the horn angle chosen, but retains the same general character.

Optimum Horn Angle for Fundamental Resonance.—There is a horn angle for which the amplification will be a maximum, assuming fundamental resonance. The optimum angle is greater the higher the frequency, 256 and 512 double vibrations being used.

Optimum Horn Angle; Overtones.—Using 512 d.v. as the fundamental

and first and second overtone, similarly 256 d.v. as the fundamental and first overtone, the optimum horn angle decreases with the order of the harmonic, being greatest for the fundamental.

End Correction.—The end correction of the conical horn is approximately 0·7 of the radius.

Conical Attachments.—Cylindrical and conical attachments to a conical horn introduce their own resonance characteristics, which may be estimated as to frequency by treating the end attached as a free open end but applying a positive correction to the length if the angle of the attached tube is less, and a negative correction if greater.

Limitations of Conclusions.—The conclusions apply strictly to the limits of frequency used in the experiment. Nevertheless they make more clear the nature of the action for all frequencies. AUTHOR.

117. *Production of Sound under Water by Condensation of Steam.* **G. Stoney** and **T. Petrie.** (Engineering, 110. pp. 561–563, Oct. 29, 1920.)—After an outline of previous work by other experimenters and other methods, the authors describe their experiments. Blowing steam into the water through a hole in a thin diaphragm, which closed the end of a $1\frac{1}{4}$-in. pipe, failed. Other attempts in which an extemporised organ pipe was sounded by a stream of water propelled by the steam and another in which a receiver 4 in. in diameter replaced the $1\frac{1}{4}$-in. pipe partially succeeded. The conditions in the latter case suggested that an unclamped water-borne diaphragm might give better results. With such a diaphragm $4\frac{1}{2}$ in. in diam., the steam from a $\frac{3}{8}$-in. nozzle impinging on a $\frac{3}{16}$-in. hole, a clear note of 600 frequency was obtained. The conditions determining the pitch and intensity of the note were investigated. The proportions and the material of the disc have no effect on the frequency. In sea trials a disc $11\frac{3}{4}$ in. in diam. and a steam pressure of 60–75 lbs. per sq. in. were used and a max. range of 11 nautical miles was attained. A laboratory investigation to determine the process by which the note is produced, conducted with the help of a stroboscope, showed that the flat surface of the disc acts as a condenser. The steam from the nozzle spreads out over the disc and is condensed, allowing the water to rush in from all sides. The water is again displaced by the steam from the nozzle and the process is repeated continually, imparting a series of pulses to the water at a frequency depending upon the velocity of the steam and the distance between the nozzle and the disc. W. H. G.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

118. *On the Theory of Electro-Capillarity.* **A. Frumkin.** (Phil. Mag. 40. pp. 363–385, Sept., 1920.)—The Lippmann-Helmholtz equation for the electro-capillary curve, $\partial\gamma/\partial\psi = \epsilon$ implies a maximum of the surface tension when the potential difference is zero. In this equation, γ = surface tension of a mercury surface, ψ = the p.d. between a decinormal calomel electrode and the mercury in the solution, ϵ = the charge on unit surface. It is found, however, that according to the electrolyte present a depression and displacement occur so that the maximum of γ corresponds to greater values of ψ. The view put forward by Gouy which is substantiated in the present work is that a p.d. between the solution and the mercury may be caused by absorbed layers of ions. According to the relation derived by Krueger, $\partial\gamma/\partial\psi = \epsilon + F(k-1)c\delta$ . . . (1), where F is 96,541 coulombs, k the distribution co-efficient of the mercury salt between the surface layer and the bulk of the solution, c the concentration of mercury salt in the solution, and δ the thickness of the surface. The concentration of Hg in KI solution, for instance, will be much higher than in the case of KCl solution, on account of the complex salt which HgI_2 gives with KI, so that the term F $(k-1)c\delta$ will, in this case, have a considerable value and cause the observed anomaly of the electro-capillary curve.

Krueger's theory is found, however, to be not applicable to the anomalous curves obtained by the addition of certain organic compounds, though, in these cases, Paschen's relation, according to which the potential of the dropping electrode corresponds to the maximum of the electro-capillary curve, still holds. Pyrogallic acid with sodium sulphate gives a variation of γ with ψ with the maximum of γ displaced in the direction of higher p.d.'s, while, with paraldehyde, the displacement is towards values of ψ lower than that given by sodium sulphate alone. In these cases, the p.d. of Solutions/Mercury is unaffected, no complex salts are therefore formed and Krueger's supplementary term vanishes. It is deduced from thermodynamical considerations, apart from any special assumptions as to the nature of the observed anomalies, that if $\partial\gamma/\partial\psi$ is zero, $\partial\psi/\partial s$ must also be zero, where s is the surface area of the mercury. Consequently, if at its max. surface tension, the potential of an insulated mass of mercury does not change when its surface is increased, *i.e.*, such a solution is a " null " one. In support of this, it is found in a series of measurements made with different solutions of organic substances with anomalous electro-capillary curves that the max. e.m.f.'s determined with a sensitive capillary electrometer, the large mercury electrode being immersed in a N/10 solution of KCl, agree closely with the e.m.f.'s of the cells: Paschen dropping electrode solution/Decinormal calomel electrode. On the above thermodynamical grounds, the following relation is also derived: $d\gamma/d\psi = \epsilon + \Gamma_{Hg}F$ . . . (2), where Γ is the excess of solute in gm.-mols. per cm. of the dividing surface.

In the case of a system such as zinc amalgam immersed in a solution

containing only zinc and an anion, it is calculated that the right-hand term in the above equation is negligible so that the surface tension of a zinc amalgam electrode in a dilute solution of a zinc salt does not depend on its potential nor, in consequence, on the concentration of the solution. If, however, there is, in the solution, a great excess of a salt with another kation, then the value of ϵ is no longer limited and its surface tension will vary with ψ and, in consequence, with the concentration of the zinc salt. This deduction is verified experimentally with solutions of $ZnSO_4$ and Na_2SO_4. Measurements made on the p.d. between dropping and still amalgam show that the addition of Na_2SO_4 to $ZnSO_4$ greatly increases the p.d. It follows that, in contradiction to Nernst's theory, the existence of a p.d. between solution and mercury is not at all connected with the exchange of ions of mercury, but that the displacement of the maximum of surface tension can only be caused by absorbed layers of anions and kations and may be called adsorption p.d.

In the Gibbs equation showing the relation between the adsorbed quantity of a substance and the lowering effect on the surface tension, whereby $\Gamma = -c/RT \cdot \partial\gamma/\partial c$, where c is the concentration of the solute, the effect of the charge of the dividing surface is neglected, and it is shown by Lewis that the values calculated from this equation in many cases deviate widely from those measured experimentally. Taking into account the energy changes involved by the ions, it is deduced that $c/RT \cdot \partial\gamma/\partial c = -(\Gamma/n)_A - (\Gamma/n)_K \ldots$ (3), where n_A and n_K represent the valencies of anion and kation, and Γ is the excess of ions in gm. equivalents per cm.^{2}. In the corresponding equation of the electrocapillary curve $1/F \cdot \partial\gamma/\partial\psi = \Gamma_A - \Gamma_K$ it is verified that with solutions of electrolytes with an active anion, namely, one which gives an electrocapillary curve with a depressed maximum, such as Br′, I′, CN′, and SCN′, the maximum is displaced to high values of ψ as compared with solutions of electrolytes with an inactive anion, such as NO_3', SO_4', OH′.

The max. surface tension in N/10 KNO_3 corresponds to $\psi = 0{\cdot}57$ volt and in N/KI to $\psi = 0{\cdot}87$ volt. The relation in the above equation was also found to be followed in the ascending and descending branches of the curve, according to the presence of excess of either anion or kation. It is shown that equation (2) may be expressed in the form of an equation of adsorption of mercury ions, or $\partial\psi = -RT/nF \cdot dc/c$; whence, in analogy to equation (3), $c/RT \cdot d\psi/dc = -1/n \cdot (\epsilon/F + \Gamma_{Hg})$. J. N. P.

119. *Electrification by Impact.* **H. F. Richards.** (Phys. Rev. 16. pp. 290–304, Oct., 1920.)—*Electrification by Impact; Measurement of the Charge Produced by Collision between a Metal and a Dielectric.*—After briefly discussing the unsuccessful attempts which have been made to formulate a satisfactory theory to explain electrification by friction, the author suggests that impact of dielectric upon metal, without sliding friction, may cause an electrical effect whose laws will shed light upon the frictional phenomenon. An apparatus is described for measuring the electric charge produced when a disc or sphere of dielectric material collides with a metal disc. The charges obtained in this manner ranged from 0·16 to 9·83 e.s. unit, and produced potentials of 2·41 to 183·8 volts upon the metallic systems employed. These charges are of the same order of magnitude as those obtained by friction. The experiment was performed with *various metals and dielectrics*, and in every instance the

metal received a positive charge. In no case was there any evidence of the erratic variation which others have found to be characteristic of electrification by friction. Curves are given which show the *variation of charge with velocity of impact* and with the *mass of the impinging system*. The charge produced by a single collision increases with each of these factors, but the velocity of impact was found to exert a greater influence than the mass of the moving body, in determining the amount of the charge. In certain cases velocities were attained at which the electrification due to a single impact reached a max. value.

Relation of Charge to Capacity.—The quantity of charge produced by a given collision was shown to be independent of the capacity of the metallic system.

Effect of Repeated Impacts.—When many impacts were performed in rapid succession, the amount of charge increased to a maximum. This maximum was shown to be conditioned rather by the quantity of charge present upon the dielectric than by the potential of the metal anvil.

Discussion of Results.—The author concludes that there is no direct dependence of the electrical energy upon the mechanical energy lost in impact, and that electrification by impact is similar in nature to the contact effect between metals. The results are considered to support Helmholtz's theory regarding the nature of electrification by friction.

AUTHOR.

120. *Electrostatic Induction.* **E[leonora] Freda.** (N. Cimento, 19. pp. 193–213, May, 1920.)—The case of a metallic strip of indefinite length is worked out in detail for various conditions. Some anomalous results are found. A. D.

121. *Atmospheric-Electric Observations made at Sobral, Brazil, during the Total Solar Eclipse of May* 29, 1919. **S. J. Mauchly** and **A. Thomson.** (Terrest. Magn. 25. pp. 41–48, June, 1920. Presented before the Am. Phys. Soc., April, 1920.)—Potential gradient and positive and negative conductivity were observed at intervals during the forenoon from May 24 to June 2. On the day of the eclipse the observations were made as nearly continuously as possible. Those made during the earlier part of the eclipse were no doubt complicated by the presence of cloud, but this began to clear 15 mins. before totality. From the beginning of totality until about 20 mins. after totality the potential-gradient observations show a well-marked minimum 20 % lower than the mean of equal periods immediately before and after. During this period of minimum, the fluctuations of potential gradient are much smaller than before and after. The positive and negative conductivities (and consequently the total conductivity) show an increase of about 20 % during the 15 mins. succeeding totality. Lastly, the air–earth current density (product of potential gradient and total conductivity) is more constant during the period in question than during any other equal period on the same morning.

M. A. G.

122. *Investigations on Lightning Discharges and on the Electric Field of Thunderstorms.* **C. T. R. Wilson.** (Roy. Soc., Phil. Trans. 221. pp. 73–115, Aug. 27, 1920.)—The induced charge on an exposed earthed conductor is used as a measure of the electric field. The conductor may be shielded from the earth's field, and the quantity of electricity flowing

between conductor and earth on exposing or shielding the former is measured by a special type of capillary electrometer, and gives a measure of the potential gradient at the beginning or end of the exposure. The electrometer is arranged to give a photographic record so that any changes in the potential gradient during the exposure, being accompanied by the passage of electricity through the instrument, are also registered. A lightning flash during a thunderstorm results in a sudden change (F) of the potential gradient, the record showing a discontinuity followed in all cases by a logarithmic " recovery " curve corresponding to a regeneration of electricity in the discharged cloud. Discharges producing a sudden positive change of potential gradient are more frequent than those producing a negative change.

As regards *quantitative results*, the mean value of the electric moment of a discharge, or the product $2Q(H_2 - H_1)$, where Q is the quantity of electricity discharged from height H_2 to height H_1, is found to differ little from 100 coulombs-km. For distant discharges the electric moment approximates to FL^3, where L is the distance, and this provides the means of measuring it, for F is obtainable from the curves and L from a record of the time of the thunder, associated with the discharge producing F. Assuming $(H_2 - H_1)$ ranges on an average from 1 km. to 5 km., then Q ranges from 10 to 50 coulombs. For a discharge of 20 coulombs the order of magnitude of the region discharged is that of a sphere of radius 250 to 500 m. ; the order of the potential reached in the cloud before discharge, 10^9 volts ; of the mean density of the charge, 100 e.s. units per $m.^3$; of the reduction of pressure within the cloud just before discharge, 1/2500 atmo. ; of the energy dissipated by the discharge, 10^{17} ergs ; and of the mean current through the cloud immediately after discharge, 3 amps. The initial slope of the " recovery " curve immediately after a discharge gives a measure of the rate of regeneration of electricity within the cloud, and the records show that if this rate were maintained the time occupied before again reaching the sparking limit would average about 7 secs. Actually the time is greater since, owing to certain neutralising processes, this rate falls off.

A *theory* is developed in which thunder and shower clouds are treated as bipolar and some of the lines of force from the upper charge are regarded as ending in a conducting layer in the upper atmosphere. In this way a current is maintained from the earth to the conducting layer, or *vice versa*, according to the sign of the polarity of the cloud, *i.e.*, the sign of the upper charge. Owing to the difference between the mobility of the carriers of positive or negative electricity, which are dragged out of the conducting layer towards the cloud head, clouds of positive and negative polarity have very different effects. The assumption of the existence of clouds of both polarities then leads to an explanation of the following observed phenomena : the preponderance in showers (1) of negative potential gradients, (2) of lightning discharges producing a sudden positive change of potential gradient, (3) of positively charged rain. There is also afforded a possible explanation of the normal positive potential gradient of fine weather.

The question is discussed of the possibility of the disruption of water drops by the electric field as the sparking limit is approached, and reasons are given to support the suggestion that " false cirrus " is constituted of the disruption products of drops which, acquiring a greatly increased velocity, are ejected from the cloud head and then freeze. M. A. G.

DISCHARGE AND OSCILLATIONS.

123. *Electron Tube Generators of Alternating Currents of Ultraradio-Frequencies.* **G. C. Southworth.** (Radio Rev. 1. pp. 577–584, Sept., 1920.)—The general form of the circuits for thermionic valve generators is given and the usual explanation of its mode of action. The use of such a circuit for the production of oscillations below a few millions of cycles per sec. introduces difficulties owing to capacity and inductive effects, complicated by the capacity effects between the valve electrodes. A circuit due to Colpitt is then illustrated, which whilst more complicated and offering disadvantages owing to capacity effects between the various pieces of apparatus, permits wave-lengths as low as 20 m. to be obtained.

A *modification of the Colpitt circuit* by the author allowed of the wave-length being further reduced to 10 m., and by a uniform distribution of capacity and an inductance of rectangular form the wave-length was reduced to 2 m. The use of this rectangular inductance with one variable side allows of its capacity and inductance being varied and also determined from its dimensions. The actual apparatus used is illustrated and its dimensions detailed. The calibration of this circuit is then described and a series of curves given for the variation of wave-length with length of side of the rectangle. Difficulties experienced in actually measuring the high-frequency currents in this circuit are described. The method adopted consisted in the use of a coupled parallel-wire circuit, the energy-transfer to which was measured by means of a thermo-couple and galvanometer. A resonance curve for such a circuit is shown, and further experiments are to be presented in a subsequent paper. B. J. L.

124. *Valency of Photo-Electrons and Photoelectric Properties of some Insulators.* **M. J. Kelly.** (Phys. Rev. 16. pp. 260–273, Oct., 1920.)—*Photo-emission from insulators; the valency of photo-electrons.*—Charged droplets of different insulators are suspended in the field of a parallel-plate condenser by regulating the strength and direction of the electric field so that the electric force on the droplet is equal and opposed to the gravitational force. Ultra-violet light of various intensities and frequencies is allowed to fall on the droplets and the photo-emission is observed. The photo-emission of several insulators is studied in this manner. By making the light intensities sufficiently low, the author finds that *only one electron escapes at each emission.* This is true for all insulators studied and is verified in the case of each insulator by the observation of several hundred emissions. This result is in line with similar work on ionisation of gases by X-rays, γ-rays, β-particles, and α-particles by Millikan and his students. By the use of different absorption screens *the long wave-length limit of photo-emission* from sulphur, shellac, oil, and paraffin is found. These are ascertained with greater accuracy than by any other methods. The effect of water-vapour and various surface impurities on photo-emission is discussed. AUTHOR.

125. *A Study of the Residual Ionisation in a Gas with Reference to Temperature Effects.* **C. H. Kunsman.** (Phys. Rev. 16. pp. 349–361, Oct., 1920.)—A form of electrometer was constructed which used the principle of the Wulf electrometer in separating the conduction of charge across the insulation from the conduction in the gas due to ionisation. *The new features of this apparatus* were that it was possible (1) to make

a quick and accurate test of the insulation properties under the same conditions as those under which the ionisation tests were made, and (2) to subject the instrument to a wide range of temperatures.

Ions generated per Cm.³ per Second.—The data experimentally determined show that the number of ions generated per cm.³ per sec. within an air-tight chamber is 8·22 in the basement of the Physical Laboratory of the University of California, and 4·15 over the Pacific Ocean.

Residual Ionisation not due to Thermal Impact.—The results of tests between −44·6° C. and 92·5° C. show no indications that the residual ionisation is due in any part to a molecular impact of thermal agitation.

Effect of Temperature on Insulation System.—Observations made of changes in temperature on the insulation system would seem to account for the apparent daily and seasonal variations of the residual ionisation as previously reported.

Conclusions from Observations at Low Temperatures.—At temperatures from −30·5° C. to −44·6° C. an increase in conduction across the insulation system was noticed, which was comparable to the apparent increase in ionisation as reported at high altitudes. It would therefore seem that it is not necessary to assume, as has been done by previous observers, that there is a highly radio-active cosmic layer in the upper atmosphere, or that the sun is a source of penetrating radiation sufficient to generate 90 ions per cm.³ per sec. AUTHOR.

126. *Excitation Potential of Mercury Vapour.* **J. Franck** and **E. Einsporn.** (Zeits. f. Physik, 2. 1. pp. 18–29, 1920.)—Measurements were made of the dependence of the photoelectric effect for an iron electrode on the velocity of the electrons, from a glowing wire, the light emission from the electrons being due to collisions with mercury molecules. Each time a new ultra-violet line is excited, due to increased velocity of the primary electrons from the glowing wire, the photoelectric current for this potential, as measured by a galvanometer, must show a more rapid rise with the potential, so that at these points kinks must always arise in the current–potential curve. The $h\nu$ relation allows the emitted wave-length to be calculated from the potentials at which these kinks occur. The termination of the series is marked by the ionisation potential, at which an ionisation current is added to the photoelectric current. Typical curves are reproduced, and after making the proper correction for the initial velocity of the electrons, an excellent agreement is obtained between the observed potentials and those calculated from the $h\nu$ relation for about 18 different wave-lengths. The difference is in no case more than 0·05 volt. The results are exhibited graphically, and give some interesting information with respect to the series lines of mercury. The research establishes with considerable exactitude the conclusions, relative to electron impacts in mercury vapour, deduced from Bohr's theory, and the method of experiment should prove useful in many cases for amplifying or supporting the results of spectral analysis. [See Abs. 659 (1913) and 1279 (1920).] A. W.

127. *Ionisation of Atmospheric Neon.* **F. Horton** and **[Miss] A. C. Davies.** (Paper read before the British Assoc., Cardiff, 1920.)—It has been found that the following are critical velocities for atmospheric neon: 11·8 volts and 17·8 volts for the production of radiation; 16·7 volts, 20·0 volts, and 22·8 volts for the production of ionisation.

The conditions under which the different critical points were indicated showed that the radiation velocity 11·8 volts is associated with the ionisation velocity 16·7 volts, and the radiation velocity 17·8 volts with the ionisation velocity 22·8 volts. No third critical velocity for radiation corresponding to the ionisation velocity 20·0 volts was detected, but it is possible that such a critical velocity occurs too close to one of the other radiation velocities to be distinguished separately. The conditions under which the various points were obtained also showed that none of the critical velocities mentioned can be attributed to the displacement of a second electron from an already ionised atom. Neon is the only gas so far investigated which has shown more than one critical velocity for the removal of a first electron from the atom.

Further information as to the ionisation of neon was sought by observing the spectrum of the luminosity produced in the gas as the electron velocity was gradually increased; for, on the generally accepted view, the line spectrum of a gas results from the recombination which occurs when ionisation has taken place. It was found that the lines of the 1st and 2nd subordinate series types required definitely higher minimum electron velocities for their production than the lines of the principal series type. The lines of the principal series types, came in at 20·0 volts, and it seems probable that the lines of the subordinate series type do not appear until the higher ionisation velocity, 22·8 volts, is reached. No lines in the visible spectrum were ever observed below 20·0 volts, although the ionisation experiments show that a considerable amount of ionisation must have been occurring.

The results of the ionisation experiments might be interpreted as indicating that atmospheric neon is a mixture of *different* elements, since isotopes would be expected to have the same critical velocities for electrons. Such a supposition is, however, not borne out by the investigation of the spectrum of the luminosity produced in atmospheric neon, for if a second element were present it would be expected that the complete spectrum of one element (including some lines in the visible spectrum) would be obtained for lower electron velocities than the spectrum of the other element, and this was not found to be the case. The authors therefore conclude that the different critical velocities found for neon correspond to the displacement of differently situated electrons within the atom, or, in other words, that the external electrons in neon are not all symmetrically situated about the nucleus. AUTHORS.

128. *Moving Striations in Neon and Helium.* **F. W. Aston** and **T. Kikuchi**. (Roy. Soc., Proc. 98. pp. 50–56, Sept. 1, 1920.)—*Neon.*—When the flash of an ordinary spectrum tube containing neon was analysed by a rotating mirror, it was found that it consisted of two parts, an extremely short flash followed by a flame or arc, and that the latter consisted of bright striations travelling from anode to kathode. The same phenomenon was observed with helium. Rough measurements of the *velocity of these striations* gave values of about 50,000 cm./sec. in neon and about 100,000 cm./sec. in helium. As these figures approximated to the velocities of sound in these gases, it was hoped that investigation of the effect might lead to an explanation of striations generally. This expectation has not been realised, as these velocities were found to be special or limiting cases of far more complex phenomena. An account is given of preliminary experiments, which have given interesting, but

somewhat inconclusive results. With neon it was found that the velocity is very roughly proportional to the inverse square root of the pressure and is greater the narrower the tube. The velocity also depends on the purity of the gas.

Effect of Impurities.—A small quantity of impurity, probably hydrogen, increases the velocity of the striations and at the same time decreases the range of pressure over which they can be observed. If the quantity of impurity becomes at all large, the striations cannot be seen at all.

Helium.—Helium gave results similar to those for neon ; its striations, however, are not so easy to observe and are usually much closer together. Experiments were tried with mercury vapour, but no trace of striations could be detected.

Other Gases —Neither air nor hydrogen showed moving striations in capillary tubes, but in a tube 1·6 mm. wide both developed stationary ones at 1 mm. to 2 mm. pressure. As the pressure was reduced these became indistinct, especially at the anode end, and moving striations could be detected by using the rotating mirror. These moving striations became more distinct, faster, and further apart, until at low pressure the discharge became an instantaneous flash. Further experiments are in progress. A. W.

129. *Theory of the High-Vacuum Discharge.* **G. Jaffe** and **J. E. Lilienfeld.** (Ann. d. Physik, 63. 2. pp. 145–174, and pp. 175–178, Sept. 28, 1920.)—Owing to the absence of theoretical information relative to the manner in which the residual gas alters the behaviour of a vacuum toward a discharge, and the fact that the experimental conditions are never those of a perfect vacuum, the author has here endeavoured to complete the Child-Langmuir space-charge theory by considering the case where the gas pressure is very small. The theory is divided into two sections, (*a*) with plane electrodes, (*b*) with cylindrical electrodes. In the former case the influence of positive ions and an initial positive gradient are considered, and in the latter the influence of the positive ions. The paper concludes with a comparison of the results of experiment with those obtained theoretically. A. E. G.

130. *Electric Conductance in Extreme Vacua. Homogeneous Röntgen Rays.* **J. E. Lilienfeld.** (Sächs. Gesell. d. Wiss. Leipzig, Ber. [Math. Phys. Kl.] 69. p. 226, 1917. Zeits. Instrumentenk. 40. pp. 185–187, Sept., 1917.—Abstract.)—In the bulb constructed for the study of the *Bremsstrahlung* [Abs. 401, 944, 945 (1918)] the incandescent wire does not serve directly as kathode. Opposite the anode A (target) is the tubular cold kathode K ; beyond K an auxiliary electrode S, and further away the hot wire G, which may be stout and of large surface to bear intense heating. The electrons emitted by G enter the bore of K, where they release other electrons ; the ratio of the bulb discharge between K and A to the ignition discharge between K and G depends upon the condition of the bore. The connections from the negative terminal of the induction coil J to the bulb contains adjustable resistances which may be inserted either between G and K, or between G and S, for the purpose of rendering the kathode K active only at the instant when the alternating-current wave is at its peak. The hardness of the tube is regulated by the aid of a resistance between G and A. The cold K gives currents of great homogeneity and constancy. Exact measurements

are very difficult, but the output of the bulb increases with the load on it. The composition of the rays is deduced from their absorption by lead and aluminium and by the ionisation of methyliodide. There is a very soft radiation making up about 20 % of the initial radiation, and this is completely absorbed by 2 mm. of Al and little dependent upon the electric relations; further, a very hard component, very selective in character, the hardness of which varies strongly with the potential and the specific load on the target focus, and thus with the current intensity. The hardness constancy observed by Rutherford, when a certain high potential is exceeded, is not confirmed, probably because in the Coolidge bulbs of Rutherford the specific load on the target focus falls off at a certain tube-load limit. H. B.

131. *The Minimum Arcing Voltage in Helium.* **K. T. Compton, E. G. Lilly, P. S. Olmstead.** (Phys. Rev. 16. pp. 282–289, Oct., 1920.) —*Helium Arc; Minimum Arcing Voltage.*—The arc was stimulated by an intense thermionic current passed between electrodes in very pure helium. 20 *volts* was found to be a well-defined minimum voltage at which the arc will strike or break, although it may be maintained on voltages as low as 8 volts after having struck.

Helium Spectrum; Voltage for Excitation of Lines and Bands.—Apparently the ordinary helium and parhelium lines and the bands are excited whenever the arc strikes. The line 4686 of the *enchanced system* was never observed below 55 volts, and was stronger above 80 volts. The lines of the *sharp subordinate series of pairs* are peculiar in that their intensity decreases, relatively to that of the rest of the spectrum, as the voltage is increased.

The results are in accord with *Bohr's theory of radiation and atomic structure.* AUTHORS.

132. *The Detecting Efficiency of the Electron Tube Amplifier.* **E. O. Hulburt** and **G. Breit.** (Phys. Rev. 16. pp. 274–281, Oct., 1920.)—*Definition of Detecting Efficiency.*—The detecting efficiency of an amplifier is defined as $\lim_{A \pm 0} \frac{b_0}{A^2}$, where b_0 is the average change in the plate current of the last tube and A is the amplitude of the impressed grid voltage.

Relative Importance of Detecting Efficiency and Input Impedance.—A discussion of the necessity of taking into account both the detecting efficiency and the input impedance is given.

Measurements of Detecting Efficiency for a Transformer-coupled Radio-Frequency Amplifier.—Measurements of the detecting efficiency of a transformer-coupled radio-frequency amplifier were made by means of a condenser potential divider and a sensitive quadrant electrometer.

Measurements of Amplification.—Measurements of the amplification due to each tube of the above amplifier were made. It was found that the *sound intensity* in the telephones was increased in the ratio of $9 \times 10^3 : 1$ owing to the use of the first two tubes. AUTHORS.

133. *Thermo E.M.F. and Alloy Research.* **J. L. Haughton.** (Inst. of Metals, J. 23. pp. 499–523, 1920. Engineering, 109, pp. 803–807, June 11, 1920.—Abstract.)—A consideration of the thermoelectric phenomena in metals. It is shown that in a metallic aggregate such as a eutectic, the distribution of the components relative to the

direction of the flow of heat will considerably affect the thermoelectric power to an extent dependent on the solubility of the metals in each other. An *apparatus* is described suitable for work on alloys up to 700° C. F. C. T.

134. *Conductivity and Frequency.* **E. D. Eastman.** (Am. Chem. Soc., J. 42. pp. 1648–1655, Aug., 1920.)—Solutions of potassium chloride, lithium chloride, or sulphuric acid were contained in a long channel the ends of which led to reservoirs in which were placed non-polarisable electrodes. These electrodes were connected in series with a standard resistance and with a source of steady current. Two similar non-polarisable electrodes led to intermediate points in the channel of liquid. By means of a potentiometer and standard resistances, measurements were made, on the Wheatstone bridge principle, of the resistance between the intermediate electrodes during the passage of a current of frequencies varying from zero, or direct current, up to a frequency of 1000. With direct current, a galvanometer was used to indicate the position of balance in the potentiometer, and in other cases a telephone. The temperature was maintained at 25° ± 0·01 deg. C. The " cell constant " was determined by replacing the electrolyte by mercury.

The difference in conductivities between those with direct current and those with current of 1000 cycles did not exceed 0·02–0·03 % in the cases studied. The slightly higher values with alternating current are concluded to be higher than the experimental error and to denote an effect due to oscillatory rotation of the polar molecules about their centres. The conductivity of N/1 potassium chloride at 25° C. given by Kohlrausch is confirmed within 0·1 % in these measurements.

J. N. P.

135. *Absolute Measurement of Resistance.* **E. Grüneisen** and **E. Giebe.** (Ann. d. Physik. 63. 2. pp. 179–200, Sept. 28, 1920. From the Physikal-Techn. Reichsanstalt.)—In this a self-inductance consisting of a single-layered coil on marble has its value in C.G.S. measure calculated from its dimensions, and its value in international units determined by measuring it in terms of a resistance and a frequency. Three coils were used, and two of them were divided into sections, so that by appropriate connections 13 different self-inductances could be built up. To calculate the self-inductance of a coil it is necessary to know the radius of the coil, the pitch, the diameter of the wire, and the number of turns, and special measuring apparatus was devised to measure these with the necessary accuracy. To measure the self-inductance in international henrys the following procedure was adopted. A coil of self-inductance L and resistance r_3 is first evaluated in terms of a capacity C, and two resistances r_1 and r_4 by a modified Maxwell bridge method. When r_1 and r_4 are the resistances in opposite arms of the bridge, the relation is $L = Cr_1r_4$. Corrections to this have to be applied. The capacity C was a series of special air condensers, and its value was determined by the Maxwell interrupter method, the equation being $C = 1/nr$, where n is the number of discharges per sec. r is not, however, a single resistance. From the two equations we have $L = r_1r_4/nr$ int. henrys. The ratio of the value of L in 10^9 centimetres to this value is the ratio of the ohm (10^9 C.G.S. units) to the international ohm. The authors, after making necessary corrections, conclude that 1 int. ohm = 1·00051 ohms

(10^9 C.G.S.). In 1913 Smith [see Abs. 955 (1914)] found 1 int. ohm = 1·00052 ohms (10^9 C.G.S.). It is possible, however, that the mercury standards used may differ by 3 parts in 100,000, so that the actual difference between the absolute determinations may be 4 parts in 100,000. F. E. S.

136. *Resonance Amplitude of the Vibration Galvanometer.* **K. Gruhn.** (Archiv f. Elektrot. 8. pp. 210–213, Oct. 10, 1920.)—The amplitude of a vibration galvanometer is a function both of electrical and mechanical variables. Assuming Zöllick's results for the effect of other variables, the author discusses the effect of frequency on amplitude. The complete solution of the expression for the resonance amplitude under various conditions is best obtained by *graphical methods* explained in the paper. J. W. T. W.

137. *Measurement of Changes in Resistance by means of Electronic Valves.* **R. T. Beatty** and **A. Gilmour.** (Phil. Mag. 40. pp. 291–295, Sept., 1920.)—A valve circuit is arranged to generate oscillations, the grid-circuit inductance being coupled to that, L, in the anode circuit, which is shunted by a condenser K. On the insertion of a high resistance, R, shunted by a condenser C, in the grid circuit, the oscillations will be broken up into equally spaced groups, and the groups thus formed will give rise to a note whose frequency is equal to the number of interruptions per sec. If the frequency of the note is plotted against the grid resistance R, a curve is obtained showing decreasing frequency with increasing R, and when R is very large the sound heard in the telephone may only occur, perhaps, once per minute. The research here described shows that such a curve only represents the final stages of a series of relations between R and the frequency f, and these relations are illustrated graphically for a wide range of values of R. The relation between f and R is shown for different values of the grid capacity C, and it is seen that as C decreases, the relation between f and R, at first approximately linear, becomes more involved. A hollow appears in the curve, and the frequency descends by a series of jumps to the bottom of this hollow, and rises again continuously as R is increased. Further reduction of C gives a silent region between two transition points. These transition points can be moved by altering the circuit arrangements.

The transition points for given values of the circuit constants are well defined, and may be utilised for measuring resistance or changes in resistance. A selenium cell of the Fournier-d'Albe pattern, of resistance 2×10^5 ohms, was used as the grid resistance. With $C = 1{\cdot}8 \times 10^{-4}$ mfd. the circuit functioned at the second transition point, and the light from a candle 20 ft. distant was sufficient to cause a note in the previously silent telephone. With the same cell and a potential of $-2{\cdot}3$ volts applied to the grid, the circuit functioned at the first transition point, where a change of resistance causes discontinuous changes in the frequency. By tuning a second circuit to unison, a marked change in the number of beats per sec. caused by the two telephone notes could be produced by a candle at a distance of 60 ft. A. W.

138. *Demonstration of Induction Currents produced in Electrolytes without Electrodes.* **A. Piccard** and **Frivold.** (Archives des Sciences, 2. pp. 264–265, May–June, 1920. Paper read before the Soc. Suisse

de Physique.)—Experiments are described which demonstrate that induced currents are produced in aqueous solutions exactly as in the case of metallic conductors. It is shown also that it is possible to measure the resistance of these solutions without using electrodes and without polarisation effects.

The method described makes use of alternating currents and string galvanometers. A. B. W.

139. *Combined Photo-Selenium and Compensation Cell.* **W. S. Gripenberg.** (Elekt. Zeits. 41. pp. 453–454, June 10, 1920.)—Selenium cells are differentially coupled with some apparatus, in order to diminish the dark current. As selenium has a high temperature coefficient, the compensating resistance should also be made of selenium, but large blocks of selenium are not homogeneous. The author hence combines a photo-cell and a compensation cell by subdividing the Se plate in such a way that sensitive ruled strips alternate with unruled strips, the strips being alternately joined to the Pt electrodes (platinum on glass) on either side of the cell. The arrangement is simple. It was observed that, when all the strips were joined in one circuit, the current fluctuated strongly, though it was steady under the same conditions in differential connection; the author ascribes this observation to an electrochemical compensation. H. B.

140. *Improvements in the Kathode-Ray Oscillograph.* **W. Rogowski.** (Archiv f. Elektrot. 9. pp. 115–120, July 8, 1920. From the Techn.-Physikal. Inst. Jena.)—It is shown that for the best operation of the kathode-ray oscillograph it is necessary to have kathode rays with the same velocity. These must be acted upon by an alternating electric field whose wave-form is triangular. If this alternating potential is obtained from the terminals of a condenser, it is essential that the condenser should be both charged and discharged with a constant current, which must be the same in both cases. This result is achieved by connecting two diode vacuum tubes in parallel, the anode of one being joined to the kathode of the second, and *vice versa*. These are in series with a condenser and a source of alternating potential which is large compared with that required to produce the saturation current in the vacuum tubes, and hence the condenser is charged at the saturation current of one vacuum tube and discharged at that of the other tube. The kathode-ray oscillograph is more suitable than the Siemens-Blondel oscillograph for large currents, high potentials, and high frequencies, and with short tubes (about 40 cm.) the same *current sensitivity* can be obtained as with ordinary oscillographs for currents of the order of 0·1 amp. The *potential sensitivity*, however, for low potentials is not quite so high as with ordinary oscillographs. [See Abs. 2009 (1908).] A. W.

141. *Experiments with Improved Kathode-Ray Oscillograph.* **W. Rogowski** and **G. Glage.** (Archiv f. Elektrot. 9. pp. 120–126, July 8, 1920. From the Techn.-Physikal. Inst., Jena.) — Experiments are described with the improved oscillograph described [see preceding Abs.]. Using a small Schott transmitting valve, graphs of the current used to charge and discharge the condenser were obtained for various alternating potentials. At 600 volts no approach to constancy of current was found either for charging or discharging. At 1400 volts the current curve

shows constancy for a little more than half the period of charge and discharge; and at 2200 volts the current curve is practically rectangular, with the same current for charge and discharge. If the filaments of the two valves used are unequally heated, the currents through the tubes are also unequal, as is shown by several graphs. Seddig receiving valves, used in the same way as the Schott transmitting valves, with anode and grid connected together, were found to give very satisfactory results, the saturation current being reached at a lower voltage than with the Schott valves. A. W.

142. *Electronic Constants of Bismuth.* **G. C. Trabacchi.** (Accad. Lincei, Atti, 28. pp. 137–142, Feb. 2, 1919.)—Corbino's recent work can be reduced to a form which leads to Drude's four electronic constants. This is experimentally verified. The variation of resistance under the action of the magnetic field alone presents anomalies; but these can be accounted for by films of oxide on the bismuth particles. A. D.

143. *Oblique Passage of Lines of Magnetic Induction from Iron to Air.* **W. Rogowski.** (Archiv f. Elektrot. 9. pp. 278–279, Oct. 10, 1920. From the Techn.-Physikal. Inst. d. Univ., Jena.)—The relation between the angle i of internal incidence of lines of induction in iron and the angle r of refraction into air is given by $\tan i = \mu \tan r$, where μ is the permeability of the iron. It is generally assumed that in consequence of the high value of μ the lines pass out from the iron at right angles to the surface. This holds for many cases, but when $\tan i$ is of the same order as μ, it can no longer be assumed, and a new form of the law is given in terms of β the complement of r, namely, $\tan \beta = \mu F \cdot dy/dx/U(100 - y)$, where F is the sectional area of the iron in cm.^{2}, U the perimeter of the iron in cm., and y the percentage leakage or scattering of the lines, referred to the value of the flux at the section for which x is zero. G. E. A.

144. *Magnetic Field near Magnetised Iron.* **L. Lehrs.** (Archiv f. Elektrot. 9. pp. 280–288, Oct. 10, 1920. From the Techn.-Physikal. Inst. d. Univ. Jena.)—Rogowski's formula [see preceding Abs.] is employed to determine the numerical value of the angle of emergence of lines of induction from iron to air. Putting $\mu F/U = p$, $dy/dx = \tan \beta$, and neglecting y in comparison with 100, integration gives the equation $y = py/100$. The curve of scattering thus leads at once to the curve of angle of emergence. The principle is illustrated by application to an Epstein bundle and to the yoke of a 2-pole, 8·6-kw., d.c. motor. [See also Abs. 497B (1912).] G. E. A.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

145. *High-Tension Transformers for X-Ray Work.* **R. S. Wright.** (Inst. El. Eng., J. 58. pp. 730–732; Disc., 732–746, Aug., 1920. Electrician, 84. p. 240, with Disc., March 12, 1920.—Abstract.)—The present unsatisfactory classification of transformers for X-ray work is pointed out, instruments being rated neither on output nor efficiency. Induction coils are still rated by spark-length, and the problem is complicated by the variation of wave-form and frequency and the inverse discharge. The

application of the milliammeter is an advance over the spark-length method, but the results vary with the particular type of instrument used.

The use of the term "efficiency" also varies, electrical efficiency being of little importance to the radiographer in comparison with other factors such as time, tubes, and plates. Furthermore, different applications of X-rays for surgical, physiological, and metallurgical purposes may call for different wave-forms of the emission. It is therefore suggested that the time is ripe for co-operation between the electrical engineer, the radiologist, and the physicist to solve the various problems.

Whilst transformer apparatus lends itself to measurement by means of the milliameter, the irregular discharge of an induction coil gives more reliable practical results. It is, however, proposed that transformer apparatus should be adopted as the basis for research work. The rating must be for very great overloads as compared to the overloads of other electrical apparatus, so that special prominence must be given to security against breakdown.

The presence of heavy brush discharges with apparatus for deep-therapy employed with great overloads, makes it necessary to use different types of instruments for therapy and radiography or to use oil-insulation.

In the *Discussion*, **W. Salomonson** pointed out that with the use of higher voltages much greater insulation is required, more easily obtained with induction coils than with transformers; and repairs can be more easily effected with the former. He also gave data of the methods of measuring coil efficiencies and results obtained with various types of coils. **C. L. Fortescue** suggested the use of thermionic rectifiers to produce high voltages for X-ray purposes and illustrated the action of such rectifiers, giving curves for efficiencies. **G. W. C. Kaye** commented upon the lack of units available to the radiographer. Spark-length results may give errors of 400 % unless sphere-gaps are used. **A. E. Barclay** pointed out that milliampere readings are no criterion as to the medical efficiency and character of discharge, and cannot be used for comparisons between transformers and induction coils. **R. C. Clinker** had found that illumination and milliampere readings are not proportional but dependent upon the use of high- or low-peak waves. He advocated the use of high-frequency generators of 1000 to 2000 cycles in order to avoid ripple production such as occurs with 50-cycle generators, needing large smoothing-out condensers. **E. A. Owen** referred to Taylor Jones's work which showed that X-rays are given for high peak voltages and not for the smaller maxima. He also referred to Levy's work with barium platino-cyanide pastilles, confirmed by the National Physical Laboratory, which showed that the milliampere readings were dependent upon the wave-form and that it is futile to increase the current *via* the tube above a certain value. **G. H. Orton** suggested that the failure of the milliammeter for transformer and coil comparisons is due to the much briefer duration of coil currents, so that probably only less than half the true current is recorded, and that if photographic tests were used the superiority of the coil would be non-existent.

B. J. L.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

146. *Ozoniser for Laboratory Work.* **Y. V. Ramaiah** and **M. V. N. Swamy.** (Chem. News, 121. p. 193, Oct. 22, 1920.)—A very brief description of an apparatus consisting of three glass tubes, fused into one another in a peculiar way; there may further be an outer aluminium tube. The electrodes are small aluminium discs so mounted at the ends of the tubes that the gas is ozonised twice before leaving. A partial vacuum is maintained simply by means of a filter pump; the apparatus is worked at ordinary temperature from an induction coil. In estimating the ozone percentage of the air or oxygen treated, the authors pass the gas through oleic acid at 40° C. H. B.

147. *Active Hydrogen.* **Y. Venkataramaiah.** (Nature, 106. pp. 46–47, Sept. 9, 1920.)—When a mixture of 3 vols. of hydrogen with 1 vol. of oxygen is exploded by means of a spark in presence of alkaline potassium permanganate solution the latter is immediately turned green, presumably owing to the formation of an active modification of hydrogen. This activated hydrogen converts an alkaline solution of indigo into indigo white, ferric chloride into ferrous chloride, potassium nitrate into potassium nitrite, arsenious acid into arsine, potassium perchlorate into potassium chloride, etc. Active hydrogen has been observed by various earlier investigators [see Abs. 170, 1316 (1917), 1015 (1920)]. T. H. P.

148. *Solidification of Metals from the Liquid State.* **C. H. Desch.** (Inst. of Metals, J. 22. pp. 241–263; Disc., 264–276, 1919. Second Report to the Beilby Prize Committee. Engineering, 108. pp. 612–615, Nov. 7, 1919.)—Evidence is given which indicates that surface tension has an important share in determining the form of the crystal grains in a solidifying metal and that such grains have a tendency to assume the shape of foam cells. This conclusion, whilst consistent with the hypothesis that foam cells are actually formed, is not in any way to be regarded as establishing that hypothesis, since it is equally in accordance with the solidification of the metal from nuclei, surface tension competing with the directive force of crystalline cohesion in determining the grain boundaries. C. O. B.

149. *Ternary Alloys of Tin-Antimony-Arsenic; Curved Crystals.* **J. E. Stead,** with notes by **L. J. Spencer.** (Inst. of Metals, J. 22. pp. 127–144; Disc., 145–148, 1919. Engineering, 108. pp. 663–667, Nov. 14, 1919.)—Discusses first of all the two binary systems, tin-antimony and tin-arsenic, and shows that in the former system the alloys containing over 7·5 % Sb contain cuboidal crystals of the compound SnSb. On re-melting this compound it is decomposed, and on slowly cooling the molten metal the crystals no longer appear as cubes, but as short plates containing intercrystalline eutectic. The crystals first formed contain more Sb than represented by SnSb, and on their surface SnSb crystallises. In the case of the SnAs system, the alloys containing between 0·05 and 10 % As contain hard plates of Sn_3As_2 compound.

In the case of alloys containing tin, antimony, and arsenic, crystals are found in a matrix, in the form of incompleted spherical shells with small or large radii, according to the rate of solidification.

It is found that whilst it requires 2·5 % As in the presence of 25 % Sb to produce slightly *curved crystals*, when the antimony is reduced to 3·75 % a percentage of As as small as 0·5 yields the curved segments. The presence of curved crystals in minerals and in metals and alloys is discussed. C. O. B.

150. *Removal of Internal Stresses in Brass by Low-Temperature Annealing.* **H. Moore** and **S. Beckinsale.** (Inst. of Metals, J. 23. pp. 225–235; Disc., 236–245, 1920. Engineering, 109. pp. 393–395, March 19, 1920.—Abstract.)—It has been found possible to remove internal stresses in the case of 70 : 30 brass, which were induced by cold working, by annealing within certain limits of temperature without any important reduction of hardness resulting. The results are given of the determination of the minimum temperature at which the stress can be completely removed and the effect on the Brinell hardness. The time of annealing is found to be an important factor. The evidence obtained indicates that a cold-worked brass article in which internal stress is present involving risk of cracking sooner or later, will invariably crack in a short time when acted upon by mercurous nitrate solution of suitable strength, and specimens free from internal stress do not crack after being submitted to the action of this solution. The minimum times in which internal stress was completely removed were found to be as follows: At 200° C., 96 hours; 225°, 48 hours; 250°, 5 hours; 275°, 1 hour; 300°, 20 minutes; 325°, 5 minutes. It was also found that the harder the brass, the lower the temperature and the shorter the time of annealing required to cause a reduction of hardness. With an initial hardness of 90 and 120 no reduction in hardness occurred by annealing up to 300° C.; with an initial hardness of 165, no important reduction occurred on annealing at temperatures up to 250°, and with an initial hardness of 200, a reduction in hardness occurred at 250° and complete softening at 300° in 5 minutes. In the case of 70 : 30 brass, cold-worked to the max. hardness (200), some reduction in hardness takes place at temperatures and times which are insufficient to remove internal stress completely. This degree of hardness is rarely obtained in brass articles and is probably never necessary. Even in brass of this hardness, internal stress may be completely removed by treatment involving only a moderate reduction of hardness. Brass, cold-worked to a hardness of 165 may be annealed for 1 hour at 275° in order completely to remove internal stress without appreciable loss of hardness. Internal stress is not removed, and does not appear to be appreciably reduced by annealing at 100° for many weeks. C. O. B.

151. *Influence of Cold-Rolling on the Physical Properties of Copper.* **F. Johnson.** (Inst. of Metals, J. 23. pp. 443–473; Disc., 474–498, 1920. Engineering, 110. pp. 257–262, Aug. 20, 1920. Abstract.)—Gives details of the cold-rolling of a sample of wire-bar copper which had been hot-rolled to a 2-in. square-section billet. The composition of the billet was: Cu, 99·94; Oxyau, 0·05. The billet was cut into 10-in. lengths which were cold-rolled into strips 1·5 in. thick by 2·167 in. wide. The strips were annealed at 850°, then pickled and dried. The strips were then cold-rolled to thicknesses varying from 1·231 in. down to 0·033 in. and

the effect of different degrees of reduction in thickness on the physical properties, tensile strength, elongation, hardness, lateral spread, specific gravity, microstructure, etc., was ascertained. The results obtained show that the tenacity and hardness are increased by the application of cold work, except at certain stages where, over a certain range, they remain constant. These may most conveniently be called "critical ranges of deformation." Corresponding with these critical ranges there occur ranges of constant elongation (of test-pieces) and during cold-rolling, ranges of constant width of strip. The present available evidence indicates that during these ranges the specific gravity either decreases or remains constant and the elastic limit increases. When the rolled strips are sectioned laterally, the hardness deformation curves of the sections indicate a substantial decrease of hardness over ranges corresponding to the above-mentioned critical ranges. These results are reviewed in connection with the two theories which have been advanced to explain the existence of these critical ranges in cold-rolled metals, namely, the allotropic and the recrystallisation theories, and the suggestion is made that the critical ranges of deformation are due to smooth slipping along preferential planes of slip, whilst increases in hardness and tenacity are due to simultaneous slipping along planes of forward and lateral slip, on which the amorphous phase is generated. C. O. B.

152. *Distribution of Phosphorus in Steel between Ac_1 and Ac_3.* **J. H. Whiteley.** (Iron and Steel Inst., J. 101. pp. 359–382; Disc., 383–387, 1920.)—In a series of hypo-eutectoid steels, containing from 0·006 to 0·12 % phosphorus heated to and maintained at temperatures between Ac_1 and Ac_3, part of the phosphorus contained in the γ iron was found to diffuse into the adjacent ferrite owing to the fact that under these conditions the P is more soluble in the latter than in the former, due to the presence of dissolved carbide in γ iron. Phosphorus diffuses extremely slowly in ferrite below 650°; above this temperature the velocity gradually increases, and above 800° it is quite rapid, a diffusion which requires four hours at 740° being completed in 15 minutes at 830°. The velocity of diffusion of phosphorus in γ iron also increases with the temperature in a similar manner, but it is never so high as that at which carbon diffuses. At or near Ac_3 the rate of diffusion suddenly diminishes. A cellular structure is produced by slowly heating steels through the critical range, and this appears to be due to the diffusion of phosphorus in the γ iron. The lowest temperature at which this structure is formed depends on the carbon content of the steel; with 0·18 % C. it occurs at 820°, and with 0·06 % C. at 870°. Owing to the fairly rapid rate at which phosphorus diffuses in γ iron above 820°, it is possible by heating sections of steel plates at a temperature just below Ac_3 to remove completely the excess of P contained in the micro-ghost lines included in the areas occupied by the γ iron. This treatment does not entirely remove the lines, for, although not so pronounced as formerly, they can still be detected by etching, even in samples containing less than 0·02 % P. From this it is concluded that their presence is due to the uneven distribution of some other substance besides phosphorus. C. O. B.

153. *Season Cracking.* **W. H. Hatfield** and **G. L. Thirkell.** (Inst. of Metals, J. 22. pp. 67–91; Disc., 92–126, 1919. Engineering, 108. pp. 456–460, Oct. 3, 1919.—Abstract.)—Contains the results of investi-

gations carried out on a brass flower bowl which had developed numerous season, or age cracks. The analysis of the metal was satisfactory, and some of the cracks were found associated with definite corrosion from the surface downwards. Micro-examination showed great differences in structure; at the bottom where little work had been necessary a normal structure was found, while towards the top the structure was typical of heavily worked metal. The cracks were found to occur mainly between the crystals, but some of them appear to run through the crystals. The Brinell hardness varied from 128 in the upper portion to 62 in the base. Annealing at 550° C. for one hour was found to render the metal soft and ductile and caused complete recrystallisation with larger grain-size than the original. Experiments carried out on the spinning of brass and nickel-silver cups are described and the stresses induced are calculated. Immersion in an acidified solution of mercurous nitrate was used to detect overworked material, this immersion causing the overworked material to crack. The internal stresses induced by spinning are given and also the figures for the worked material after annealing at 100°, 250°, and 450° C. for 4 hours. These results show that the stresses themselves may approach the ultimate strength of the metal and that annealing at 450° practically dissipates them.

The results are discussed and compared with those of other workers; the theory of Rosenhain and Archbutt is considered to be unsatisfactory in view of the new facts, and the authors suggest that season cracking is due to the fact that stresses have been put upon the material, at any rate locally, of such a high order that the normal breaking-down point of such cold-worked material has been reached. In an appendix the method of calculating the stress is given. C. O. B.

154. *The Constitution, Hardening, and Tempering of High Speed Steel.* **K. Honda** and **T. Murakami.** (Iron and Steel Inst., J. 101. pp. 647–657, 1920. Abstract from 32nd Report of the Iron and Steel Research Inst. of Japan. Tôhoku Univ. Sci. Reports, 9. pp. 143–168, April, 1920.)—The results of a research are given which had as its object the ascertainment of the form in which chromium and tungsten exist in the normal condition of high-speed steel, the change of these constituents during heating and cooling, and the effect of these constituents upon hardening and tempering. It is shown that in an annealed state a steel containing 5 % Cr, 18 W, and 0·6 carbon consists of iron-dissolving tungstide, free tungstide, and the carbides Cr_4C and WC in the free state. If the steel be heated above Ac1, the carbides dissolve in austenite and undergo the following changes: $2Cr_4C = Cr_3C_2 + 5Cr$ and $2WC + 3Cr + 4Fe = 2Fe_2W + Cr_3C_2$. The higher the temperature, the more these changes proceed from left to right, but in the normal cooling from a high temperature the reverse change takes place slightly, and therefore at room temperatures the steels contain carbides, chromium, and tungstide, all in solid solution; that is, a hardened steel.

High-speed steels show the lowering of the transformations during cooling from a sufficiently high temperature. The self-hardening of these steels being intimately related to the lowering, it follows that the larger the lowering the more the transformation is suppressed. During heating, a hardened steel increases its magnetisation by the separation of the carbides from the solid solution, that is, by tempering, and the degree of tempering may be conveniently studied by means of magnetic heating

curves. The tempering of a hardened high-speed steel takes place in two steps, at about 400° and 700° respectively. The self-hardening and resistance to tempering principally depend on the quantity of dissolved Cr_3C_2 in iron containing chromium and tungstide; hence these increase with the contents of Cr and C conjointly. The max. temperature reached and the rate of cooling also have effect. Tungsten diminishes the max. temperature at which, during cooling, the self-hardening property of the steel begins to take place. When the W exceeds 12 % it exists as fine globules of Fe_2W, and these behave in tool-steel by increasing the cutting efficiency rather than in intensifying the hardness. These fine globules of tungstide are readily coloured brown to black by immersing the specimen in cold alkaline solution of ferricyanide for 10 to 15 seconds. The tungstide segregates as a eutectic during cooling from the melt. In a tool-steel, however, it is necessary that the tungstide be scattered uniformly throughout the whole mass. C. O. B.

155. *Effects of Hydrogen on Copper.* **W. C. Hothersall** and **E. L. Rhead.** (Inst. of Metals, J. 23. pp. 367–376; Disc., 377–380, 1920. Engineering, 109. pp. 391–393, March 19, 1920.—Abstract.)—Deals with the results of experiments carried out to determine the effect of the passage of hydrogen through molten copper on the properties of the metal when cast. Under suitable conditions copper thus treated will cast sound, although the same copper deoxidised by means of carbon will not produce sound castings. The copper treated with hydrogen is liable to pipe badly unless a comparatively large amount of arsenic is present. Solid copper is capable of retaining a certain amount of hydrogen in solution.

C. O. B.

156. *Model for Representing the Constitution of Ternary Alloys.* **W. Rosenhain.** (Inst. of Metals, J. 23. pp. 247–254; Disc., 255–259, 1920. Engineering, 109. pp. 527–529, April 16, 1920.)—The models previously used have the great disadvantage that only one surface or group of surfaces can be seen at one time, and it is difficult to grasp the inter-relation of the various changes which the alloys undergo. In the author's models successive sections of the whole model are drawn or painted on suitably spaced sheets of glass or celluloid, and these successive sections as seen through the transparent sheets form a general view of the contours of all the surfaces.

Unfortunately the transparency of a series of sheets of glass is not very great, and only a dim vista of the structure as a whole can be obtained. An alternative method is described in which wires of various thicknesses and colours are used with satisfactory results. C. O. B.

157. *The Electron Affinity of the Sulphur Atom.* **M. Born** and **E[lisabeth] Bormann.** (Zeits. f. Physik, 1. 3. pp. 250–255, 1920.)—Calculations are made on the zinc-sulphide crystal lattice and on the constituents similar to the calculations respecting the halogen atoms [Abs. 528 (1920)], in order to decide whether the sulphur atom is able to take up two electrons under loss of energy in accordance with Kossel's theory. The affinities found are E = $\overline{\text{Cl}}$ 119, $\overline{\text{Br}}$ 84, $\overline{\text{I}}$ 77, $\overline{\text{S}}$ 50; sulphur has, hence, an affinity for 2 electrons, but it is smaller than the affinities of the halogens for 1 electron; this would agree with Kossel's view on the electrochemical

character of the elements. The E would correspond to a sulphur potential of 2·15 volts. In testing the result by the ionisation of H_2S into $2H^+ + 2S^- + J_{H_2S}$, the conclusion is deduced that the halogen hydrides HCl, etc., should have the same constitution as the halide salts, which seems to be fatal to the theory. But HCl, etc., are volatile; NaCl, etc., have very low vapour pressures; in the solid acids the molecules are the bricks, in the salts the ions. H. B.

158. *Crystal Lattices of the Halogen Hydrides.* **A. Reis.** (Zeits. f. Physik, 1. 4. pp. 299–308, 1920.)—We know the melting-points of solid HCl, HBr, HI, but very little more. The densities are estimated at 1·4, 2·5, 3·2, the heats of sublimation at 3·6, 4·7, 5 cals. per mol. Accepting these figures, the author calculates the crystal lattices of the hydrides on the lines of Born [compare preceding Abstract] and Fajans. It is found that the relation between energy of ionisation and molecular volume of the hydrides does not follow Born's analogy of the alkali halides. Similarly the high energy value of the ionisation and the low heat of sublimation of the three acids (HF is left out of the consideration) suggests that the lattice structure of the solid acids must be molecular, not ionic; in molecular lattices the constituent lattice groups of atoms are all equal, in ionic and atomic lattices the groups of atoms are not equal according to the author [*ibid.*, pp. 204–220]. From the lattice structure of solid HCl, etc., it follows further that the structure of the halogen ions must be strongly asymmetric in the molecules. H. B.

159. *Thermo-Chemistry of Ionisation of Vapours of Certain Compounds.* **P. D. Foote** and **F. L. Mohler.** (Washington Acad. Sci., J. 10. pp. 435–444, Sept., 1920.)—If a compound in the state of vapour ionises by dissociation, it is sometimes possible to compute from chemical and physical data the value of the ionisation potential. As an example, the method of calculating the amount of work necessary to ionise 1 gm.-molecule of sodium chloride is given, the only unknown term being the heat of sublimation. The case of halides of metals of the second group is also considered; in this case the heats of sublimation may be calculated from the vapour pressures. The value thus calculated for the ionisation potential of hydrogen chloride is in good agreement with that observed by the authors, while that for hydrogen sulphide corresponds with Born and Bormann's calculation [Abs. 157 (1921)]. The values calculated for hydrogen bromide and iodide are also given. T. H. P.

160. *Constituents formed by the Reciprocal Penetration of Zinc and Copper in the Solid State.* **H. Weiss.** (Comptes Rendus, 171. pp. 108–111, July 12, 1920.)—Contains the results of the microscopical examination of the products formed by the interpenetration of copper and zinc at temperatures below 419°. In order to obtain good contact, samples of copper or brass were immersed in molten zinc and rapidly cooled or else a cylinder of zinc was forced into a hole in a cylinder of copper. Both methods are found to give similar results, although the first method has the disadvantage of causing the formation of a thin layer of brass between the copper and zinc. After heating for 2 days at 400°, the following constituents were detected: pure zinc or its solid solution

η; the constituent ϵ 0·2 mm. thick; the constituent γ about 1 mm. thick; a very thin zone of constituent β; and lastly copper or its solid solution α. By increasing the duration of heating to 10 days the thickness of the ϵ and γ zones are found to increase to 1·2 and 1·5 mm. respectively, without any increase in β constituent. C. O. B.

161. *Copper-Nickel-Zinc Alloys.* **L. Guillet.** (Rev. de Mét. 17. pp. 484–493, July, 1920. Comptes Rendus, 171. pp. 172–173, July 19, 1920.)—Refers to work published in 1913 relating especially to alloys containing Cu 55, Ni 2, Zn 43, and Cu 50, Ni 5, Zn 45, and gives the results of recent experimental work carried out with a view of ascertaining the effect of lowering the Cu content below 50 and increasing the Ni content.

The alloys examined contained from 50 to 25 Cu, 4 to 26 Ni, the balance, about 48 %, being Zn. The colour of the alloys varied from pale yellow to silver-white. The results of hot forging and rolling tests are given, and it is shown that there is a distinct relationship between the temperatures of forging and the transformation temperatures. The results of mechanical tests on 15 alloys as cast and as rolled are given, and it is found that it is possible to obtain alloys breaking at 60 kg./mm.^{2} with 18 % elongation, or breaking at 50 kg./mm.^{2} with 45 % elongation. From the point of view of mechanical properties, the most remarkable alloy is that containing 46 Cu, 10 Ni. The effect of replacing Zn by Pb in the alloy containing Cu 45, Ni 10 is shown to be negligible on the mechanical properties of the rolled material, provided the Pb does not exceed 2–3 %.

Curves are given showing the variation of resistance to shock and of hardness, with rising temperature. The results obtained confirm those previously obtained, and indicate that Ni plays a part in brasses as important as the part it plays in steel. [See Abs. 1345 (1920).] C. O. B.

162. *Diffusion of Solid Copper in Liquid Aluminium.* **R. J. Anderson.** (Chem. and Met. Eng. 23. pp. 575–577, Sept. 22, 1920.)—Describes laboratory experiments in which copper rods were dipped in molten Al under definite conditions and the resulting alloys analysed. It is shown that solid copper goes into solution in liquid Al fairly rapidly at relatively low temperatures, and that the rate of solubility and diffusion increases rapidly with rising temperatures. Small pieces of copper go into solution fairly rapidly at 700° C. and very rapidly at 900° C., indicating that the commercial method of manufacturing Al-Cu alloys by adding copper directly to Al is a rational procedure from a metallurgical standpoint. [See Abs. 19 (1919).] C. O. B.

163. *A Suggested Method for Determining the Comparative Efficiency of Certain Combinations of Alloys in Steel.* **J. D. Cutter.** (Chem. and Met. Eng. 23. p. 636, Sept. 29, 1920. Abstract of paper read before the Am. Soc. for Steel Treating.)—The suggested formula is:

$$\text{Efficiency} = \frac{\frac{1}{2}(\text{E.L.} + \text{M.S.}) \times \text{E. \%}}{100 - \text{R.A. \%}} \div (\text{lbs. ferro-alloy} \times \text{unit cost}),$$

where E.L. = elastic limit, M.S. = max. stress, E. % = percentage elongation, R.A. = percentage reduction in area. F. C. T.

164. *Studies of the Macrostructure of Cast Steel.* **F. G. Allison** and **W. M. Rock.** (Chem. and Met. Eng. 23. pp. 383–389, Sept. 1, 1920.)—

The method of development of the macrostructure used is that due to Humfrey. Hot-cast steel shows a marked dendritic structure in which the dendrites may appear in areas with parallel arrangement. With a low casting temperature definite dendrites are less obvious. Annealing for 5 hours at 1000° C. does not produce any marked alteration in the macrostructure. The use of the cerium-lanthanum alloy "Cela" as a killing agent to the extent of 0·15 % does not confer any obvious benefit. Structures are shown in which isolated areas of a dendritic structure occur in a field almost devoid of obvious dendrites. At the surface the structure may often be equiaxed, after which dendrites appear growing towards the centre. It is considered that the macrostructure of cast steel cannot be accounted for on the supposition that phosphorus and oxygen are the only controlling factors. Carbon, Mn, and Si, and, if present, such elements as Ni and Cr, play an important part. F. C. T.

165. *Properties and Microstructure of Heat-Treated Non-Magnetic Flame-, Acid-, and Rust-Resisting Steel.* **C. M. Johnson.** (Chem. and Met. Eng. 23. p. 568, Sept. 22, 1920. Abstract of paper read before the Am. Soc. for Steel Treating.)—Analysis not given. Carbon, 0·3–0·4 %. Annealed at 1300° C. complex ingot structure reverts to homogeneous solid solution, Brinell 160. Tempering for several days results in precipitation and spheroidalisation of a second constituent. It is quite non-magnetic; $B_{rem} = 4$. The following table offers a comparison with other materials of corrosion properties, the figures representing loss in gm. per sq. in. in 24 hours:

	Glacial Acetic.	10 % H_2SO_4.	32 % HNO_3.	19 % HCl.
New steel	6·1	3·2	0·4	33·3
Monel metal.....	0·7	1·3	soluble	13·1
High-Chromium Si steel ..	0·0	soluble	0·5	—
38 % Ni steel	13·8	4·1	soluble	19·0
High-Chromium steel	0·7	soluble	0·1	soluble

The mechanical properties of the new steel are:

	Yield-point.	Maximum Stress.	Elongation, %.	Reduction in Area, %.	Brinell Hardness.
Heated 5 mins. at 2400° F.	90,000	120,000	30	45	230
Oil-quenched from 2000° F.	60,000	11,000	50	60	200

The metal can be forged, rolled, or sheared in thicknesses 0·1–1 in. and is machinable. It offers a max. resistance to prolonged heating up to 2000° F., and is with difficulty cut with the oxy-acetylene flame.

F. C. T.

166. *Cyanide Hardening due to Nitrogen.* **G. R. Brophy** and **S. B. Leiter.** (Chem. and Met. Eng. 23. p. 568, Sept. 22, 1920. Abstract

of paper read before the Am. Soc. for Steel Treating.)—The pearlitic structures due to carbon and nitrogen are indistinguishable when etched with picric or nitric acid. Stead's reagent has little effect on the former, but blackens nitride. Steel case-hardened in cyanide contains much nitrogenised material. Nitrogen is believed to exert an appreciable influence on the properties of steel so treated. A 0·04 % carbon steel immersed for 4 hours in cyanide will have 0·33 % carbon on the surface, and when quenched resist a file. The Brinell hardness will be only 207. Even after subsequent annealing the cyanided bar is hard to file. If the case be ground off, the rod is still brittle, and remains so after annealing. F. C. T.

167. *Copper-Cobalt-Zinc Alloys.* **L. Guillet.** (Rev. de Mét. 17. pp. 494–500, July, 1920.)—Gives reproductions of the diagrams of the binary series, Cu-Ni, Cu-Co, Ni-Zn and Co-Zn. For the experimental work described, three series of alloys were made, containing 70, 60, and 55 % Cu, with approximately 1, 2, and 5 % Co in each series, the balance being Zn. Photomicrographs of these alloys are given, and photomacrographs show that the presence of Co has a great influence on the grain size, rendering this much finer. Results of mechanical tests on the cast alloys are noted which are somewhat irregular, but in the case of the 55 % copper alloy, show increases in ultimate strength and in elongation with increased Co content. The temperatures of transformation are also given, and it is concluded that although to a limited extent the effect of Co on brasses is similar to that of Ni, the results indicate that these alloys are of no industrial value. C. O. B.

168. *Estimating Impurities by Means of the Melting-Point Curve.* **W. P. White.** (J. Phys. Chem. 24. pp. 393–416, May, 1920.)—The conditions are considered under which Hüttner and Tammann's method for estimating the proportion of impurity in a substance by examination of the behaviour of the temperature during crystallisation [Abs. 1306 (1905)] is most likely to be useful, the technique of the method being also discussed.

The results of the experiments made show that freezing-points may be more accurately determined by immersion of the thermometer in the substance than by the capillary tube method. If, in addition, the form of the freezing-point curve is observed, an indication is obtained of the amount of impurity independently of any knowledge or uncertainty as to the melting-point of the pure substance, and even of the absolute accuracy of the thermometer employed. If the determinations are made to control a purification process, time is saved and certain serious chances of error are avoided. Smallness of the melting-point tube diminishes local temperature differences and often serves advantageously to replace stirring of the substance, besides economising time and material. A small thermo-couple or cell of several couples lends itself well to use with small test samples. The complications, usually almost negligible, arising from specific heat, uneven temperature, and other causes are considered and experimental arrangements suggested for their avoidance. T. H. P.

169. *Rate of Dissolution of Metallic Copper in Aqueous Ammonia.* I. **E. Yamasaki.** (Tôhoku Univ. Sci. Reports, 9. pp. 169–220, June,

1920.)—Investigation of the rate of dissolution of copper in ammonium hydroxide solution—the metal being rotated vigorously in the solution and a steady current of purified air passed through the latter—shows that two independent chemical reactions take place in the liquid: electrolytic dissolution of the copper, and the autocatalytic reaction of cuprammonium compound in solution. The velocity of the former reaction is proportional to the square root of the concentration of the oxygen in the solution, and the velocity of the latter to that of the cuprammonium compound; the total velocity of the reactions of the system is, however, independent of the concentration of free ammonia and the nature of the anions. As the concentration of free cupric and hydroxyl ions increases, the velocity of the reaction is subject to a complex disturbance, owing to accumulation of cuprammonium hydroxide in the solution. The velocity does not increase steadily with the concentration of the complex hydroxide, but attains a max. value at a certain concentration of this hydroxide, which is practically proportional to the concentration of free ammonia. The velocity of the reaction is approximately proportional to the two-thirds power of the rate of stirring. The temperature coefficient of the reaction is 1·15 per 10°, this low value being due to the heterogeneity of the reaction. The influence of variation of other experimental conditions and of addition of various compounds was also investigated. Owing to the industrial value of cuprammonium hydroxide in the manufacture of artificial silk, the best conditions for the preparation of this compound are discussed. T. H. P.

170. *Problem of the Equation of State.* **C. Dieterici.** (Ann. d. Physik, 62. 1. pp. 75–94, May 20, 1920.)—Various relations are deduced from the pressure isotherms obtained for isopentane by Young (1899) and for carbon dioxide and ethylene by Amagat (1893). T. H. P.

171. *Volume and Heat of Hydration of the Ions.* **M. Born.** (Zeits. f. Physik, 1. 1. pp. 45–48, 1920.)—From the author's formulæ for the lattice energy of binary salts, Fajans [Abs. 272 and 644 (1920)] had calculated the heat of hydration of the ions, by which he understands the work (W) to be done to despatch the ions from the aqueous solution of a salt into the vacuum. The deductions involve several uncertain assumptions, especially as to Ostwald's calculations of the heat of solution of the hydrogen ions in arriving at the "absolute potential." Yet the main idea seems to be correct. Fajans has pointed out that the heat of hydration increases as the ionic volume decreases, and has explained this part by an electrostatic interpretation of the process of hydration. The author works out Nernst's suggestion that the electric attraction between the ions is the smaller, the higher the dielectric constant of the medium, assuming the water to form a continuous medium electrically polarisable. For an ion of valency z and radius r_i he then finds $W = 1·64 \times 10^{-6} z^2/r_i$ in kg. cals.; the W would always be positive, contrary to the early values of Fajans for the halogen ions and also to Haber [Abs. 497 (1920)]. Comparing the r_i thus deduced with the atomic radii r_a the author finds regularities which—if not accidental, as he thinks quite possible—would signify that a positive ion is produced when the outermost electrons are torn off the atom; the ionic volume

would hence be smaller than the atomic volume. A negative ion would be produced by the reception of electrons into the atom, and the ionic volume would then be larger than that of the atom. But the W calculations and our definitions of the respective volumes are too indefinite. H. B.

172. *Size of Alkali Kations and Halogen Anions.* **A. Heydweiller.** (Zeits. f. Physik, 1. 4. pp. 393–394, 1920.)—Referring to Born and Landé [Abs. 1029 (1920)], the author adds to their tables of ionic radii values from his determinations of ionic refraction [Abs. 1752 (1913)]. There is agreement except as to fluorine, about the refraction of which the author is himself doubtful. Contrary to Landé, both the lithium and the iodine ions would appear to be closely packed in the crystal, which would account for the exceptionally small volume change observed both in the dissolution of LiI in water and in its ionisation. H. B.

173. *Heat of Sublimation and Valency-Forces of the Carbon Modifications.* **K. Fajans.** (Zeits. f. Physik, 1. 1. pp. 101–118, 1920, compare Deutsch. Chem. Gesell., Ber. 53. pp. 643–655, 1920.)—When a hydrocarbon like ethane C_2H_6 is burned, the C—H linking has to be dissolved, which requires x cals., as well as the C—C linking (y cals.); H_2O (v cals. per H atom) and CO_2 (z cals. per C atom) are formed, and the combustion yields 370·9 cals. Hence:—$6x + 6v - y + 2z = 370{\cdot}9$ cals. The combustion of propane C_3H_8 yields 526·7 cals., and by subtracting the former value from the latter we find the heat of combustion corresponding to CH_2: $-2x + 2v - y + z = 155{\cdot}8$ cals. It is shown that the x value of the C—C remains fairly constant when other elements (not H) are attached to C. Similarly the value: $z - 2y = 99 \pm 8$ cals. is deduced. In the solid diamond the y' value of the C—C link need not be the same as the y of aliphatic compounds. To burn diamond we have first to convert the solid carbon into monatomic vapour (heat of sublimation of diamond $2y'$), and then to burn this vapour to $CO_2(z)$; the heat of combustion of diamond is 94·4; hence $z - 2y' = 94{\cdot}4$ cals., and $y' - y = 2 \pm 4$ cals.; in other words, the energy required to dissolve the linking C—C is very nearly the same for diamond as for aliphatic compounds. It becomes all the more important to determine the heat of sublimation of diamond exactly. From the energy difference between a solid and its vapour and the considerations of atomic heat and thermal expansion, Grüneisen has deduced the value 274 cals. From Lummer's experiments on the temperature of the carbon arc—constant and independent of the current intensity at normal pressure, but increasing as the pressure rises from 0·1 to 22 atmos.—the author finds the sublimation heat of carbon to be 282·5 cals. at 4200° abs. In both these deductions it is assumed that the carbon vapour is monatomic, and Lummer's curves are not vapour-pressure curves in the strict sense. Moreover, Nernst's heat theorem gives the much lower value 140 cals. This, however, involves a relation between brightness and temperature, which Lummer himself questions. But if $2y' = 287$ cals., and $y = 143$ cals., then $z = 381$ cals., v being known to be $74{\cdot}4 \pm 2{\cdot}8$ cals. (Franck and others), x should be 115 cals. This $y = 143$ cals., must not be confounded with the heat dissociation of the carbon molecule C_2; it refers to the linking C—C; C=C would be associated with the development of $(2y - 20)$ cals. and C≡C with

$(3y - 43)$ cals. In graphite each carbon atom is not equally linked with 4 others as in diamond (Debye and Scherrer), but only with 3 in the same plane and with a fourth in another plane; here $y'' = \frac{4}{3}y'$, the heats of combustion of diamond and graphite being practically the same. Amorphous carbon differs, according to Debye and Scherrer, from graphite only in having molecules of a smaller number of atoms, not more than 30 possibly. If that were so, the heat of combustion of amorphous carbon should exceed that of graphite by 40 cals., whilst the excess amounts barely to 3 cals. Possibly the groups of 30 atoms are only structural elements, and do not really form the particles of powdered carbon; the linkage between a marginal atom and only 2 or 1 internal atoms might also be stronger than the average linkage with 3 atoms. H. B.

174. *Annealing of Electrolytic Iron.* **J. Cournot.** (Comptes Rendus, 171. pp. 170–171, July 19, 1920.)—Electrolytic iron has to be heated to higher temperatures and for longer periods than is assumed for it to lose its hardness. The author tested small plates, 3 cm. square, stamped out of a sheet of electrolytic iron, 6 mm. thick, originally of Brinell hardness 164. The plates were heated up to 650, 750, 850, 950, 1050°; after ten minutes the hardness was 161, 155, 135, 103, 88; after 1 hour 159, 151, 107, 88, 83. Micrographic examination showed twinning in the iron, which is ascribed to iron hydride and which still existed at 750°, only disappearing at 850°. But the annealing is not complete even after 4 hours' heating to 850° for 4 hours; it requires 2 hours' heating to 950° or 1 hour's heating to 1050°. H. B.

175. *The Colloid Mill.* **H. Plauson.** (Chemiker Zeitung, 44. pp. 533–535, July 27, and pp. 565–567, July 29, 1920. Engineering, 110. pp. 429–430, Oct. 1, 1920.—Abstract.)—By means of a special disintegrator (not described), the colloid mill, particles of 0·001 mm. and less can be obtained which in the presence of protective colloids yield colloidal solutions or emulsions of high stability. A machine of this type made by Emil Passburg, Berlin, to the design of B. Bloch, is in use in Hamburg; mention is made of German Patent No. 289,026 of 1916, granted to G. Hanning. Various applications of the colloid mill are described, and its possibilities are outlined. From natural oil sludges, which cannot be distilled, from Baku the author recovered most of the naphtha by milling the sludge with water for 5 minutes; the separated naphtha still contained up to 8 per cent. of sludge, but could be distilled. Coal and lignite are converted into a Diesel-engine fuel by mixing 30 parts with 70 of tar oil or other oil in the mill for several hours; a syrupy liquid is obtained to which finally water may be added; water is best avoided in the first instance, whilst other solutions are prepared with water. The fine grinding, preceded by rough grinding, is very useful in the dye and soap industries, for lixiviation, etc. H. B.

176. *Influence of Hydrogen Sulphide on the Occlusion of Hydrogen by Palladium.* II. **E. B. Maxted.** (Chem. Soc. J., Trans. 117. pp. 1280–1288, Oct., 1920.)—Having shown [Abs. 167 (1920)] that the occlusion of hydrogen by palladium is inhibited by small quantities of H_2S, the author investigates the quantitative relations of these reactions. As the H_2S increases, the occlusive power of the Pd for hydrogen diminishes;

the primary, almost instantaneous, absorption is, beyond a critical value of H_2S, followed by a secondary period of absorption, during which the Pd_4S apparently formed is dissociated, palladium itself acting as catalyst also in this dissociation. The nature of the complex Pd_4S is not yet clear. H. B.

177. *Photochemical Decomposition of Hydrogen Peroxide.* **C. Winther.** (Kgl. Danske Videnskabernes Selskab. 2. No. 1. pp. 1–18, 1920.)—Kistiakowsky observed in 1900 that mixtures of potassium ferro- and ferri-cyanide act as optical sensitisers in the decomposition of hydrogen peroxide. The decomposition continues after a brief insulation in the dark, a catalyst of great stability being formed, which seems to be colloidal (Weigert and Amann). The solution becomes alkaline by the insulation and, according to Henri and Wurmser, the decomposition of H_2O_2 is retarded by bases in the light, but accelerated in the dark. The author and S. Weibel expose solutions of the ferro-cyanides in various concentrations, to rays from a quartz mercury-lamp, passed through light-filters, for various periods (up to 18 minutes) with the solutions then with H_2O_2 and determine the decomposition after 30 minutes or shorter intervals. The rate of decomposition increases slowly at first to a constant maximum and can be calculated when the rate of formation of the catalyst and the rate of its action on H_2O_2 in the dark are known. It is noted that the solution of mixed ferro-cyanides turns green; the complex chemical reactions are not studied. H. B.

178. *Electrical Conductivity of Solid and Fused Salts; Activity-Coefficients of Ions in Solid Salts.* **J. C. Ghosh.** (Chem. Soc. J., Trans. 117. pp. 823–830, July, 1920.)—The author calculates from first-principles a formula for the electrical conductivity of a solid salt at different temperatures, which involves the melting-point and one unknown constant: it is therefore possible to test this formula against the temperature coefficients of a series of salts, as determined experimentally. This has been done for NaCl, KCl, AgCl, AgBr, HCl, HBr, HI, and a remarkable agreement is found between the observed and calculated values. The energy absorbed in the ionisation of these seven salts is calculated to be 51·2 and 50·9 for the two alkali chlorides, 25·6 and 24·8 for the two silver salts, 23·75, 21·67, and 18·7 for the three thallous salts. The activity coefficients, α, at temperatures within about 10 deg. of the melting-point, are of the order of 80 %, falling to the order of 10 % at temperatures 100 deg. below the melting-point. The author's results are in harmony with the view, already expressed by Lorenz and by Arndt, that in a fused salt all the ions are free, the variations of conductivity depending entirely on changes in the mobility of the ions. T. M. L.

179. *The Non-Mechanical Nature of Chemical Processes.* **M. Polanyi.** (Zeits. f. Physik, 1. 4. pp. 337–344, 1920.)—Even for the simplest reactions a velocity law has not yet been formulated compatible with the general reaction isochor. The present author now attempts to find such conceptions as to the nature of chemical transformation as will allow of the deduction of kinetic laws that are thermodynamically valid. As a preliminary to the general question he now investigates whether it is permissible to accept the mechanical laws as holding good for chemical

processes, and concludes from two independent lines of argument that this is not the case. This result signifies not only that the application of the quantum hypothesis to chemical processes cannot be combined with mechanical interpretation, but that quanta assumptions of any kind are invalid. Section I deals with the application of the quantum hypothesis. It has often been asserted that the quantum hypothesis is incompatible with mechanics, but Ehrenfest [see Abs. 759 (1920)] has shown this only to be true when the Ergoden hypothesis is also accepted. The author therefore investigates whether by modification of the Ergoden hypothesis it is possible to reconcile the quantum hypothesis with mechanics, and finds in certain processes, such as those of chemical transformation and change in state of aggregation, that the quantum hypothesis is in direct conflict with mechanical ideas.

Velocity of Dissociation of Bromine.—Section 2 contains an account of the velocity of dissociation of bromine. The observed velocity is found to be 300,000 times greater than that calculated on the basis of statistical mechanics, and gives effectual support to the conception of the non-mechanical nature of the process. H. H. Ho.

180. *The Penetration of Iron by Hydrogen.* **T. S. Fuller.** (Gen. El. Rev., 23. pp. 702–711, Aug., 1920.)—The absorption of hydrogen by steel at the kathode during electro-plating has been found to lead to embrittlement of the metal. An investigation of the phenomenon is made by the use of seamless iron tubes, 12 in. long, $\frac{1}{1}\frac{1}{6}$ in. outside diam. and with a wall $\frac{1}{1}\frac{1}{6}$ in. thick. The tubes were sealed at the top to U-tubes, one arm of which was of 2 cm.^{3} capacity, calibrated and closed at the top, while the second arm was left open. The apparatus was completely filled with mercury and a number of these were placed vertically in a water-bath to enable them to be heated to any desired temperature. The iron tubes were surrounded by different solutions contained in wider surrounding vessels and in some cases connected to an electrical circuit so that the iron tubes acted as kathodes during electrolysis of the solution with Pt anodes. The rate of hydrogen penetration was measured under different conditions. The amount of penetration is as high when exposed to 1 % sulphuric acid without current as with units electrolysed as kathode in a similar solution. In the former case, at a temperature of 20° C., a volume of 2 cm.^{3} hydrogen was collected after 48 hours. Temperature has a marked influence on the rate. With a current of 0·2 amp., a unit made kathode in 1 % sulphuric acid gives 2 cm.^{3} hydrogen in 48 hours at 20° C. and in 3·5 hours at 90° C. The penetration velocity increases with each successive electrolysis. The effect of rest or moderate heating is to restore the original resistance of the iron to the passage of hydrogen. The velocities of penetration for units electrolysed in 1 % solutions of potassium sulphate and of sodium hydroxide and in tap-water are about equal and are one-twelfth to one-fifteenth of the value with units electrolysed in 1 % sulphuric acid.

In presence of water or steam without electrolysis at temperatures from 50° to 100° C., the hydrogen penetrates the metal at a rate depending directly on the temperature. In these cases the oxide, which is one of the products of the reaction, forms a coating of increasing thickness on the metal and finally protects the iron from further action. The results obtained for nickel steel are the same as for iron. Copper is impervious to hydrogen at a temperature of 20° C. The passage of

hydrogen through iron is apparently facilitated by the presence of a coating of tin and retarded by one of zinc or copper. The presence of 1 % potassium dichromate in 1 % sulphuric acid either with or without electrolysis prevented the passage of hydrogen through the iron for at least 96 hours.

The results are explained by the formation of atomic hydrogen which is either liberated by the current or by the reaction between metal and solution. While penetrating the iron, gaseous or molecular hydrogen is later formed, and can only escape slowly as a pressure sufficient to force the gas through the metal is built up.

The phenomenon of the cracking of hardened steel when treated with acid is also attributed to a pressure built up in the above manner.

J. N. P.

181. *Electro-Affinity of Aluminium.* III. *Acidity and Constitution of Aluminic Acid.* **J. Heyrovský.** (Chem. Soc. J., Trans. 117. pp. 1013–1024, Sept., 1920.)—The acidic character of aluminium hydroxide (suggested by Slade and others) is confirmed by experiments with caustic soda and ammonia. The soda is prepared from sodium amalgam and conductivity water, and aluminium is then dissolved in the caustic. The conductivity of the solution (experiments at 0° C., to prevent decomposition of the aluminate) decreases as the Al : Na proportion rises to 1 : 1 ; more Al is not dissolved ; on the addition of Al amalgam, however, the solution takes up an excess of aluminium hydroxide, but the conductivity remains unchanged. Measurements of the e.m.f. were also made. The high solubility of the aluminium hydrate in ammonia had been stated (by others) to vary with time and mode of preparation. Working at 25° and at 0° with amalgamated Al, the authors obtained concordant results ; the conductivity increased with increasing Al, which is exceedingly soluble in ammonia ; the saturated solutions deposited microscopic crystals of aluminium hydroxide, while the conductivity decreased. Thus aluminium hydroxide appears to be both feebly basic and more strongly acidic. The aluminates seem to be additive compounds of the aquo-aluminic acid $H^{\cdot}[Al(OH)_4]$. [See Abs. 780 (1920).] H. B.

182. *The Ionisation Potential of Hydrochloric Acid and the Electron Affinity of Chlorine.* **P. D. Foote** and **F. L. Mohler.** (Am. Chem. Soc., J. 42. pp. 1832–1839, Sept., 1920.)—Purified hydrochloric acid gas was admitted at pressures from 0·15 to 0·30 mm. into a Pyrex glass ionisation chamber of the 4-electrode type, containing a hot wire of either Pt or Mo, with a cylindrical net surrounding it and, at some distance, a second concentric cylindrical net and outer cylinder and Pt electrodes. The electrons were accelerated between the hot wire and the inner net by a potential difference V. A portion of these passed through the net into the space between the two nets, which were maintained at the same potential and, if of sufficient velocity, produced ionisation. The positive ions diffused into the space between the outer net and cylinder, which were connected through a galvanometer to a potential of such magnitude and sign that no electrons could pass through. The galvanometer showed zero deflection as the accelerating voltage was increased until this reached the ionisation potential, at which point an ionic current is observed. The final mean value obtained for the ionisation potential is 14·0 volts.

That the effect is not due to hydrogen is shown by the disappearance of the characteristic ionisation when using a trap of liquid air to condense the hydrochloric acid.

Constitution of the HCl Molecule.—It is concluded that the HCl molecule consists of a positively charged H-atom and a negatively charged Cl-atom bonded together and that the ionisation simply disrupts this bond. It is assumed that the gain in energy by the production of the negative chlorine atom assists in the ionisation of HCl and that the collision of an electron of sufficient velocity with the HCl molecule results in the immediate production of a positively-charged atom of hydrogen and negatively charged atom of Cl. The work necessary to ionise a gm.-molecule of HCl is accordingly given by the expression: $J_{HCl} = J_H + Q_{HCl} + D_H + D_{Cl} - E_{Cl}$, where J_H is the work required to ionise a gm.-atom of H, Q_{HCl} is the heat of formation of one gm.-molecule of HCl from H_2 and Cl_2, D_H half the heat of dissociation of a gm.-molecule of H_2 into monatomic hydrogen, D_{Cl} half the heat of dissociation of a gm.-molecule of Cl_2 into monatomic chlorine, and E_{Cl} the amount of energy to be expended to remove the electron from one gm.-atom of the negative Cl ion and reduce it to a neutral condition. The value of E_{Cl} is determined from the potential energy of the crystal system in the case of a halogen salt by applying the formula derived by Born, which evaluates the work required to convert a gm.-molecule of the crystal into free positive and negative ions and by substituting known values for the heat of formation of the salt, the latent heat of sublimation of the metal, the ionisation potential in kg. cals. of the neutral metal atoms per gm.-atom, and the heat of dissociation of Cl_2. The mean value of E_{Cl} per gm.-atom is computed as 119 kg. cals., corresponding to 5·2 volts. Replacing this and the other known values in the expression for the ionisation of HCl, $J_{HCl} = 312 + 22 + 45 + 56 - 119 = 316$ kg. cals./gm.-mol. wt. = 13·7 volts/molecule, a result which is in close agreement with the experimentally found value. It is noteworthy that the *attraction between a hydrogen nucleus and a halogen* ion is found to be about the same as that between the hydrogen nucleus and the electron in the neutral hydrogen atom. J. N. P.

183. *Temperature Function of the E.M.F. of Galvanic Couples (Weston Cell).* **H. v. Steinwehr.** (Zeits. f. Physik, 1. 3. pp. 261–270, 1920.)—Starting from Helmholtz's equation $U = A(E - T\,dE/dT)$, where U designates the change in the total energy, E the e.m.f., and A the constant factor $nF\eta$ (n = number of equivalents transformed, F = coulombs per equivalent, η = conversion factor of caloric into electric energy) and from Kirchhoff's $dU/dT = \Sigma S$, some of the atomic and molecular heats, the author arrives at an equation for E containing the constants k and k', defined by $-\Sigma S k'/A = k$. The k' can be determined in 3 ways, according as: (1) U and E are known for some particular temperature; (2) dE/dT is known for some temperature; (3) U and the approximate variation of E are known. The formulæ deduced are applied to the Weston normal cell with $CdSO_4$, $8/3H_2O$. For the temperature coefficients of the e.m.f. we have the formulæ of Jaeger and Wachsmuth, and of Wolff. Both yield approximately the same U; but they differ as to the max. e.m.f., the two values being − 9° (Jaeger) and + 3° (Wolff), and still more as to the dU/dT. Neither of the two formulæ is exact. Determining the dU/dT from thermochemical data

and taking the variation of the specific heats of the various constituents with temperature into consideration (accepting the values of the Reichsanstalt, 1919, of Kruisheer 1916, and Holsboer 1902, etc.), the author arrives at a new table for the deviation of the e.m.f. of the Weston cell for different temperatures between 0 and + 30° from the value at 20° and an empirical formula for E. The Jaeger formula would appear to be the more correct for temperatures up to 15°, the Wolff formula for higher temperatures. H. B.

184. *Electromotive Activity of Carbon Monoxide.* **F. Auerbach.** (Zeits. Elektrochem. 25. pp. 82–84, March 1, 1919.)—With respect to Hofmann [see Abs. 935 (1920)], the author points out that the e.m.f. which Hofmann calculates for the gas cell O_2/CO cannot directly be compared to the energy of the reaction $2CO + O_2 \rightleftarrows 2CO_2$, because in the alkaline cells of Hofmann the CO is oxidised to alkali carbonate and not to CO_2. The e.m.f. realised is hence much smaller. H. B.

185. *Polarity of the Aluminium Cell.* **F. Streintz.** (Phys. Zeits. 21. pp. 477–480, Sept. 15, 1920.)—When diluted sulphuric acid is electrolysed with an anode of aluminium, the anode becomes coated with a grey film, and the polarisation observed seems to be partly galvanic and partly dielectric. According to G. Schulze the dielectric consists not merely of the film of hydroxide, but also of gaseous oxygen retained in the film. The author investigates how far this polarisation is analogous to the unipolar conductivity observed between crystals of sulphides and metals [see Abs. 912 (1920)]. In both cases a gas condenser of variable capacity intervenes; in the crystal that gas film is pre-existent, in the Al-cell it is being formed. Indicating as in the paper quoted the ends of the crystal by 1, 2 and the current direction by the sequence of these figures, i_{21} would be the current intensity for the case when Al is the kathode, and i_{12} the intensity for Al anode. In the experiments with crystals the unipolarity U was found to be $U = (i_{21} - i_{12})/i_{21}$, and the product UV to be a constant (V being the potential). Experimenting with two Al electrodes in sulphuric acid, and a platinum foil, suspended between the two plane Al-foils, the author entirely confirms the formula for U. The constancy of the second relation only becomes apparent when high potentials, above 30 volts, are applied. But the experiments had to be made on different days, the cells being used in the intervals, whilst with the crystals the observations were continuous. [The paper is a first communication.] H. B.

186. *The Electromotive Behaviour of Aluminium.* **A. Smits.** (K. Akad. Amsterdam, Proc. 22. Nos. 9 and 10, pp. 876–881, 1920.)—The passivity of Al during anodic polarisation has been attributed to the formation of a layer of alumina of high resistance. Though a coating of oxide or basic salt is formed at higher potentials, this explanation cannot be reconciled with the fact that at lower potentials, where passivity is also shown, the Al anode remains bright, and that when the current is reversed the resistance disappears. The observed phenomena are related to the operation of electromotive equilibria. On anodic polarisation, it is found that the potential of the metal becomes so strongly positive that the tension necessary for the separation of oxygen is reached already with very low current-densities. The change of the potential in the noble

direction is regarded as the primary phenomenon and the separation of oxygen and subsequent oxide formation as the secondary. The ennobling of the potential of Al is explained by the withdrawal of electrons from the metal being immediately followed by the Al ions going into solution, but that the formation of Al ions in the solid metal in accordance with the reaction $Al \longrightarrow Al^{\cdots} + 3\ominus$ proceeds with very low velocity.

The presence of oxygen would appear to act as a negative catalyst for the setting in of the internal metal equilibrium, hence the small quantity of oxygen absorbed by the metal on anodic polarisation has a greatly retarding effect with Al, as in the case with Fe, Co, and Ni. Through the withdrawal of electrons and ions, the metal surface passes into a state which resembles a metalloid and possesses an exceedingly small electrical conductivity. The Al surface becomes therefore a metal coating of great electrical resistance, and this coating is in turn surrounded by another of alumina.

The immediate destruction of anodic polarisation on reversal of the current is explained by the fact that hydrogen, just as oxygen, though in a smaller degree, is a negative catalyst for the establishment of the internal metal equilibrium, but yet apparently acts positively catalytically when it separates on a metal surface that has previously absorbed oxygen, since both negative catalysts then disappear with the formation of water.

A strongly positive catalytic influence is exerted by halogen ions and accounts for the absence of the polarisation effects in their presence. J. N. P.

187. *Electro-analytical Separation of Nickel (Cobalt) from Arsenic.* **N. H. Furman.** (Am. Chem. Soc., J. 42. pp. 1789–1793, Sept., 1920.)—It is found that in electrolysing ammoniacal solutions containing alkali arsenates and nickel alone, the Ni deposits are free from As. On the other hand, with similar solutions containing Co and As, the deposited metal contains As in amounts ranging from 6·0 to 12·0 mgm. per 0·1 gm. of Co. With nickel and cobalt in equal proportions together with As, from 0·5 to 1·0 mgm. of As was found in 0·1 gm. deposit of the mixed metals.

The experiments made consisted in adding known amounts of dihydrogen potassium arsenate (KH_2AsO_4) to a standardised nickel sulphate solution, together with 2 gm. of ammonium sulphate and 15 cm.^{3} of ammonium hydroxide (sp. gr. 0·90) in a total volume of 100 to 125 cm.^{3} The amount of Ni deposited by a current of 0·46 to 0·61 amp. on a kathode surface of 55 cm.^{2} at a voltage of 3·3 to 3·8 applied for 10–12 hours, agreed closely with the known weight of As taken while no appreciable weight of As was present in the deposit. By the use of a rotating anode and high current-density, a complete separation and deposition of the Ni in presence of As could be brought about in 25 to 75 mins.

The method is successfully applied to the determination of nickel in the mineral niccolite (arsenide of nickel) by dissolving in acids, precipitating iron with ammonia and electrolysing. J. N. P.